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SERIALS

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Akademiya Nauk SSSR, Izvestiya, Geologic Series, in English translation (American Geological Institute). Washington, D.C.
Akademiya Nauk SSSR, Izvestiya, Geophysics Series, in English translation (American Geophysical Union). New York.
Alabama, Geological Survey, Information Series. University.
American Association of Petroleum Geologists, Bulletin. Tulsa, Oklahoma.
American Ceramic Society, Journal. Easton, Pennsylvania.
American Geological Institute, AGI Data Sheet. Washington, D.C.
American Journal of Science. New Haven, Connecticut.
American Mineralogist (Mineralogical Society of America). Ann Arbor, Michigan.
American Society of Civil Engineers, Soil Mechanics and Foundations Division, Journal. New York.
Arizona Geological Society, Digest. Tucson.
Canada, Geological Survey, Bulletin; Map; Paper. Ottawa.
Canadian Journal of Botany (National Research Council of Canada). Ottawa.
Canadian Journal of Chemistry (National Research Council of Canada). Ottawa.
Canadian Mining and Metallurgical Bulletin. Montreal.
Carnegie Institution of Washington, Geophysical Laboratory, Paper. Washington, D.C.
Edmonton Geological Society, Quarterly. Edmonton, Alberta.
Florida, Geological Survey, Information Circular; Report of Investigations. Tallahassee.
Focus (American Geographical Society). New York.
Geochimica et Cosmochimica Acta. London-New York.
Geological Society of America, Bulletin. New York.
GeoTimes (American Geological Institute). Washington, D.C.
IGY World Data Center A, IGY General Report (National Academy of Sciences). Washington, D.C.
Indiana, Geological Survey, Bulletin; Mineral Economics Series; Miscellaneous Map; Report of Progress. Bloomington.
International Geology Review (American Geological Institute). Washington, D.C.
Journal of Geology. Chicago.
Journal of Geophysical Research. Washington, D.C.
Journal of Sedimentary Petrology. Tulsa, Oklahoma.
Kristallografiya. Soviet Physics: Crystallography; a translation of the journal Crystallography of the Academy of Sciences, U.S.S.R. (American Institute of Physics). New York.
Life. Chicago.
Michigan, Geological Survey Division, Progress Report. Lansing.
Mining Engineering (American Institute of Mining, Metallurgical and Petroleum Engineers). New York.
Missouri, Division of Geological Survey and Water Resources, Biennial Report. Rolla.
Montana, Bureau of Mines and Geology, Bulletin. Butte.
National Research Council of Canada, Associate Committee on Soil and Snow Mechanics, Technical Memorandum. Ottawa.
Nevada, Dept. of Conservation and Natural Resources, Ground-Water Resources-Reconnaissance Series, Report. Carson City.
New York Times. New York.
Ohio, Division of Water, Technical Report. Columbus.
Oil and Gas Journal. Tulsa, Oklahoma.
Ontario, Dept. of Mines, Annual Report; Preliminary Map; Provisional Map. Toronto.
Ontario, Fuel Board, Annual Report. Toronto.
Oregon, Dept. of Geology and Mineral Industries, Biennial Report; Bulletin. Portland.
Reader's Digest. Pleasantville, New York.
Research Council of Alberta, Preliminary Report; Report. Edmonton.
Science. Washington, D.C.
Seismological Society of America, Eastern Section, Earthquake Notes. [Washington, D.C. ?].
Texas, University, Bureau of Economic Geology, Report of Investigations. Austin.
U. S. Geological Survey, Bulletin; Professional Paper; Reports, Open-File Series; Water-Supply Paper. Washington, D.C.
Washington, Division of Water Resources, Water Supply Bulletin. Olympia.

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GeoScience Abstracts

1. GEOLOGIC MAPS, AREAL AND REGIONAL GEOLOGY

PART 1. GEOLOGIC MAPS

See also: Areal and Regional Geology 3-1755, 3-1764; Structural Geology 3-1800; Geohydrology 3-2004, 3-2005, 3-2012, 3-2014, 3-2016; Mineral Deposits 3-2037; Fuels 3-2083.

3-1748. Ontario, Dept. of Mines. ESPANOLA SHEET: Its: Prelim. Map P. 105, scale 1 in. to 2 mi., 1961.

3-1749. Ontario, Dept. of Mines. MILLIGAN, DISTRICT OF COCHRANE: Its: Prelim. Map P. 104, scale 1 in. to 1/4 mi., 1961.

The western part of Milligan township is covered by a large esker with abundant kettles and small kettle lakes. A number of sand dunes lie to the E. of this esker. A small discontinuous esker covers parts of lots 1, 2, and 3. Much of the remainder of the township is covered by glacial lake clay and silt, with numerous small bog deposits. The central part of the township is quite swampy.

The few rock outcrops in Milligan township generally stand prominently above the glacial deposits. A series of pillowed and massive basic lavas have been intruded by coarse-grained to medium-grained basic rocks. A small amount of acid lava was observed.

The intrusive rocks include coarse-grained gabbro, composed of amphibole and pyroxene and minor feldspar; immediately to the N. of the gabbro, a sill of diorite; diabasic quartz diorite, with obvious amounts of green epidote throughout the rock, in the southeastern part of the township and N. of the gabbro and diorite noted above.

A single outcrop of well bedded siltstone and graywacke occurs.

The rocks trend northwesterly, although there are local deviations from this trend. Outcrop exposures are too few to establish a good picture of the structure.

The magnetic contours, taken from Map 296G of the Geological Survey of Canada, indicate continuity of a Keweenawan diabase dike across the township, and suggest that a northwesterly dike branches off from the main dike.

No evidence of significant quartz or sulfide mineralization was seen.--Auth.

3-1750. Ontario, Dept. of Mines. WALKER, DISTRICT OF COCHRANE: Its: Prelim. Map P. 103, scale 1 in. to 1/4 mi., 1961.

Much of Walker township is covered by varved clay and silt of glacial lake origin. A few small bog deposits occur SW. of the Black River; bog deposits are extensive in the northeastern part of the township. The topography is gently rolling except where large outcrop areas rise 30 to 70 ft. above the overburden.

The outcropping Precambrian rocks consist largely of acid, intermediate, and basic lavas intruded by northerly-trending diabase dikes generally considered to be of Matachewan age. The acid volcanic rocks are for the most part agglomerates with oval to angular fragments up to 1 1/2 ft. in length. A small outcrop of spherulitic rhyolite was found. The intermediate lavas were named dacite, although no thin section examinations have been made. These rocks are hard, flinty gray in color, and weather readily to a rust or cream color. They commonly contain minor amounts of finely disseminated pyrite. They characteristically have poorly developed pillow structure, and commonly change along strike to pyroclastic rocks. The basic lavas are uniform or pillowed. One distinctive flow of pillowed basic lava is porphyritic within pillows. None of the pink to cream phenocrysts was seen to cross pillow margins.

Sedimentary rocks are reported to occur in concession 1, S. of the Pipestone fault. The fault is indicated by magnetic surveys outlining ultrabasic masses and by drilling in areas short distances to the E. and W. of Walker township. An E.-W. synclinal axis passes through the town of Monteith. The N. limb is overturned, dipping steeply N. A parallel anticlinal axis lies about 1 mi. to the N.

A number of quartz-carbonate-epidote-axinite veins were observed. Only a few small grains of pyrite were found in the veins. Two old shafts were sunk by the Silver Foam Mining Co. before 1918 in lot 10, concession 2. Grab samples from the dumps yielded no Au.

Aeromagnetic contours taken from Map 297G of the Geological Survey of Canada indicate the trends of diabase dikes. Anomalies in concessions 2 and 5, lots 3 and 4, do not appear to indicate diabase dikes. --From auth.

3-1751. Ontario, Dept. of Mines. PART OF COLEMAN TOWNSHIP, CON. V & VI - LOTS 1-6, DISTRICT OF TIMISKAMING, ONTARIO: Its: Provisional Map P-97, scale 1 in. to 400 ft., 1961.

3-1752. Walker, Frank H., and R. Dee Rarick. **MAP OF INDIANA SHOWING CRUDE OIL, NATURAL GAS, AND REFINED PETROLEUM PRODUCTS PIPELINES:** Indiana, Geol. Survey, Misc. Map no. 6, scale 1:500,000, 1960.

This map shows the principal pipelines. Locations of refineries, pumping or compressor stations, and underground gas storage fields are indicated by standardized petroleum industry symbols. Tables show ownership of pipelines, refineries, and underground gas storage fields and list the capacity of Indiana refineries. An inset map provides information on pipelines and refineries of the Lake County Calumet district.--Auth.

3-1753. Munger, Averill H., and E. Placidi, comps. PETROLEUM DEVELOPMENTS AND GENERALIZED GEOLOGY OF AFRICA AND MIDDLE EAST. Geological compilation by Edward A. Gribi, Jr.: 115 p., maps, Munger Oil Information Service, 5865 West Boulevard, Los Angeles 43, California, Oct. 1960.

Contains base maps of 80 countries with geological overlays. Base maps show well locations, well drilling, oil, gas, and water wells; oil and gas fields; pipelines; outlines of concessions; elevation points; roads and railroads. Geological overlays indicate volcanic, basement, Paleozoic, Mesozoic, and Tertiary rocks and alluvium.--A. C. Sangree.

PART 2. AREAL AND REGIONAL GEOLOGY

See also: Stratigraphy 3-1822; Mineral Deposits 3-2044.

3-1754. Lacy, W.C. GEOLOGY OF THE DUNCHURCH AREA, ONTARIO, CANADA: Geol. Soc. America, Bull., v. 71, no. 11, p. 1713-1717, 2 maps (1 fold.), sec., 3 tables, Nov. 1960, 4 refs.

The mapped area is about 20 mi. NE. of Parry

Sound, Ontario, and constitutes the NE. portion of the Sundridge map sheet. The area is in the westernmost part of the Grenville subprovince and contains rocks typical of the Grenville series farther E. Two distinct variations of Grenville rocks are represented: 1) an upper unit composed of metasedimentary rocks and marble, and 2) a lower(?) unit, the Ahmic gneiss, consisting of well-banded microcline-biotite and garnet amphibolite gneisses and quartzite. Rock units strike generally N. to NE. and dip steeply eastward. The structure is characterized by broad domes occupied by massive to gneissic rocks ranging in composition from granite to anorthosite. The interdomal areas are occupied by isoclinally folded metasedimentary rocks that show little metamorphic effects of adjacent domical plutons. Faulting is minor in the area.--B. W. Pipkin.

3-1755. Kretz, Ralph. GEOLOGICAL OBSERVATIONS IN NORTHERN NEW QUEBEC: Canada, Geol. Survey, Paper 60-12, 17 p., Map 13-1960 (in pocket), scale 1:1,013,760, 1960, 15 refs.

This report is concerned with an area of approximately 45,000 sq. mi. in northern Ungava. In July and Aug. 1959 a Dominion Observatory expedition entered the region to make gravity measurements. The writer was attached to that expedition to collect geological information. Although a complete knowledge of the geology in so large an area could not be obtained in the limited time, an attempt was made to detect regional variations of metamorphic grade and structural style. Considerable attention was given to glacial geology.

Although the early geological explorations in northern Ungava were confined to the seaboard, they nevertheless established the major rock units, which may be summarized as follows: 1) inclusions in granitic rocks, the remnants of a gneissic, pre-granite terrain; 2) granitic rocks; 3) gneisses and migmatites of the northern seaboard; 4) Cape Smith-Wakeham Bay belt, predominantly gabbroic rocks; 5) northern part of the Labrador Trough, predominantly metamorphosed sedimentary and gabbroic rocks; 6) Manitounuk group (along the western seaboard), slightly disturbed and slightly metamorphosed basalt and sedimentary rocks; 7) diabase dikes.

The present report deals with the granitic rocks and their inclusions, the gneisses and migmatites of the northern seaboard, rocks of the Cape Smith-Wakeham Bay belt, and the diabase dikes. The Manitounuk group of rocks found at the Hopewell Islands were not examined by the writer and are not discussed.

Glacial features such as moraines, drumlins, striae, glacial valleys, eskers, and kames are abundant and indicate that ice moved radially from central New Quebec during late Pleistocene time.--From auth., p. 1, 5, 14.

3-1756. Kentucky, Geological Society. FIELD TRIP 1961. GEOLOGIC FEATURES OF THE CUMBERLAND GAP AREA, KENTUCKY, TENNESSEE, AND VIRGINIA; by Kenneth J. Englund and Leonard D. Harris: 30 p., 13 figs. incl. maps, secs., Apr. 1961, 3 refs.

This excursion of the Geological Society of Kentucky is in the Cumberland Gap area of Kentucky, Tennessee, and Virginia. Much of the area is in the Cumberland Gap National Historical Park, well-known to the visitor for its numerous historic and scenic attractions. To the geologist this area in the heart of the Cumberland overthrust block offers many features of structural and stratigraphic interest. In addition to folds, cross faults, and overthrusts, the rocks exhibit a variety of facies changes. There are examples of stream piracy, cave development, and in the vicinity of Middlesboro, extensive flood-plain and terrace alluviation. The economic importance of the outcropping rocks is indicated by limestone quarries, contour strip mining in coal-bearing strata, and exploration for oil and gas in nearby areas. The objective of this excursion is to traverse the belt of outcropping formations southeastward from Cumberland Gap and examine representative outcrops showing critical stratigraphic and structural features.--Introd.

3-1757. Heindl, L. A., and John F. Lance. TOPOGRAPHIC, PHYSIOGRAPHIC, AND STRUCTURAL SUBDIVISIONS OF ARIZONA: Arizona Geol. Soc., Digest, v. 3, p. 12-18, 2 figs., 1960, 15 refs.

This paper briefly reviews the existing schemes of topographic, physiographic and structural boundaries in Arizona and proposes the use of a boundary based on structural differences, as they are now understood, to separate the Colorado Plateau and Basin and Range provinces.--From auth. introd.

3-1758. Heindl, L. A. GEOLOGY OF THE LOWER BONITA CREEK AREA (A PRELIMINARY REPORT): Arizona Geol. Soc., Digest, v. 3, p. 35-39, map, 1960, 3 refs.

The lower Bonita Creek area, Arizona, includes the southeasternmost part of the Gila Mountains, the western slopes of Turtle Mountain, and the dissected valley between them. The mountains are tilted fault blocks composed predominantly of volcanic rocks, and the valley area is underlain principally by dissected alluvial deposits. The rocks range in age from probably Cretaceous to Quaternary. Age designations are made on the basis of lithologic similarity to or continuity with rocks of known or accepted age. No fossils have been found in this area.--From auth., p. 35.

3-1759. Davidson, Edward S. GEOLOGY OF THE EASTERN PART OF THE SAFFORD BASIN, GRAHAM COUNTY, ARIZONA, (A PRELIMINARY REPORT): Arizona Geol. Soc., Digest, v. 3, p. 123-126, fig., 1960, ref.

Several sedimentary geologic units occur in the Safford basin: the stratigraphically lowest sediment is the basin fill; overlying it are gravels which cap the terraces that extend in steps from the Gila River to the mountain edges; and alluvium beneath the present flood plain of the Gila River. The alluvium is the youngest sediment within the mapped area.--From auth. introd.

3-1760. Marlowe, James I. LATE CENOZOIC GEOLOGY OF THE LOWER SAFFORD VALLEY - A PRELIMINARY REPORT: Arizona Geol. Soc., Digest, v. 3, p. 127-129, 1960, 5 refs.

Late Cenozoic terrestrial sediments occur in the lower Safford trough to an unknown depth, and form a relatively soft valley fill which is cut by a well-defined pediment surface. Subsequent downcutting has resulted in an intricately dissected badland topography over most of the area. In the vicinity of the San Carlos Reservoir, lava flows are interbedded with the basin sediments and a number of small basaltic plugs have intruded the basin fill.--From auth. introd.

3-1761. Harbour, Jerry. SEDIMENTOLOGY AND STRATIGRAPHY OF THE BASIN-FILL SEDIMENTS IN THE SAFFORD VALLEY: Arizona Geol. Soc., Digest, v. 3, p. 131-132, 1960.

Late Tertiary sediments in the Safford basin consist predominantly of fine-grained floodplain deposits, with smaller quantities of river gravels and lacustrine beds. The major part of the sediments can be recognized as the older basin fill, which comprises the bulk of the basin sediments, and the much younger inter-valley fill, which generally occupies the axial area of the valley and is related to recent cutting and filling by the Gila and San Simon rivers. --From auth., p. 131.

3-1762. Shreveport Geological Society. GUIDE BOOK, 1960 SPRING FIELD TRIP, APRIL 1-2, 1960. INTERIOR SALT DOMES AND TERTIARY STRATIGRAPHY OF NORTH LOUISIANA: 147 p., maps, secs., pls., P.O. Box 750, Shreveport, Louisiana, 1960, approx. 200 refs. (not seen at AGI).

The purpose of the field trip and the guidebook is to stimulate geological thinking concerning interior salt domes and Tertiary stratigraphy. The book is divided into 2 parts. The first part is a series of 5 professional articles about salt domes, 2 tabulations, and an exhaustive bibliography as follows:

Interior Salt Domes of Texas, Louisiana and Mississippi, by G. C. Clark.
Minden Salt Dome, by P. H. Richardson.
Correlation Problem - Minden Dome (Paleontologic Interpretation), by E. G. Anderson.
The Winnfield Salt Dome, Winn Parish, Louisiana, by H. C. Belchic.
Liquified Petroleum Gas Storage in Arcadia Salt Dome, by N. C. Skrivanos and R. G. Norton.
Tabulation of North Louisiana Salt Domes, by B. W. Blanpied.
Tabulation of Wells Which Have Encountered Salt or Cap Rock in North Louisiana and South Arkansas, by E. H. Lambert, Jr.
Selected Bibliography Relating to Salt Domes with Particular Emphasis on Interior Domes.

The second part of the book concerns the field trip. "A Guided Geological Tour Through North and Central Louisiana," by C. O. Durham, Jr., and W. S. White, Jr., reviews the geological setting of the trip. The 2-day road log is accompanied by a large index map, 16 strip maps and 15 plates. The first day's route is through the N. Louisiana salt dome basin and is designed so that at each stop a greater amount of surface expression of the salt domes can be seen. The second day's trip covers the entire Tertiary section along the S. flank of the Sabine platform. The road log, by C. O. Durham, Jr., is followed by a selected bibliography.--E. H. Lambert, Jr.

3-1763. Mississippi Geological Society. GUIDE BOOK, 15TH FIELD TRIP. CENOZOIC OF SOUTHEAST MISSISSIPPI AND SOUTHWEST ALABAMA. MAY 12-14, 1960: 52 p., illus., maps, secs., Box 999, Jackson, Mississippi, 1960, refs.

The field trip covers a broad area of representative outcrops and examples of Gulf Coast Cenozoic sedimentation. The area traversed encompasses the eastern half of the buried Mississippi interior salt basin, currently, as well as historically, the scene of intensive, competitive, oil and gas exploration and discovery. Sizeable reserves have been established in beds ranging in age from Tertiary to Jurassic. It is becoming more apparent each year that sedimentary character, both local and regional, has a tremendous controlling effect on the localization of commercial reserves. A better working knowledge of the history of the Gulf Coast and its environmental zones should be most beneficial to the understanding of the exploration problems encountered in older, but genetically similar, phases of Gulf Coast geosynclinal development.

Examples of the complex, and often repetitive, relationships of marine plain development, barrier bars, lagoons, fluvial plains and channels are viewed on this trip in the hope of engendering ideas for further thought, examination, and eventual application in the various branches of geologic exploration.

Application of surface structural geology throughout the Gulf Coast has resulted, both directly and indirectly, in the discovery of oil productive structures. A look at the surface expression of the Hatchetigbee anticline, or the impressively large displacement along the surface trace of the Jackson fault in western Alabama, should prove that subsurface structures and basement structural lineaments have left many discernible clues for identification by the surface geologist.

The trip is designed to supplement and tie together the more detailed Mississippi Geological Society Tertiary trips of 1948, Sixth Field Trip - Upper Eocene, Oligocene and Lower Miocene of Central Mississippi; 1952, Ninth Field Trip - Claiborne of Western Alabama and Eastern Mississippi; and 1953, Tenth Field Trip - Wilcox and Midway Groups, West-Central, Alabama, adding more recent examples and locations of newer road cuts, road logs, quarry descriptions, fossil localities and possible substitute type sections for additional study. Secondly, this trip further extends these previous field trip studies into a reconnaissance of the Quaternary formations with an investigation, as well as a literature review, of the Pliocene, Pleistocene, and Recent of the Mississippi and Alabama coastal areas. Some of the indirect effects of the various glacial stage activities are shown as well as the more direct effects of current sedimentation and erosional processes along the present coast.

A generalized geologic section is presented for reference to the over-all relationships and correlative nomenclature for the Cenozoic formations of Mississippi and Alabama. These formations, however, are charted and described in greater detail in the maps and sections accompanying the individual daily road logs.--From foreword by F. X. Bland.

3-1764. Zen, E-an. STRATIGRAPHY AND STRUCTURE AT THE NORTH END OF THE TACONIC RANGE IN WEST-CENTRAL VERMONT: Geol. Soc. America, Bull., v. 72, no. 2, p. 293-338, 7 figs., 5 pls. incl. 2 col. geol. maps, scale 1:48,000, 2 tables, Feb. 1961, 68 refs.

The stratigraphy of the Taconic sequence at the N. end of the Taconic Range in W.-central Vermont has been revised as follows:

Pawlet formation: interbedded black slate and greywacke; Middle Ordovician.
Mount Hamilton group: undivided black, gray, green, and red argillite, with minor limestone, limestone conglomerate, and ankeritic quartzite; Upper

Cambrian to Middle Ordovician.

West Castleton formation: black slate and phyllite, with a limestone unit near the base; Lower Cambrian.

Bull formation: Lower Cambrian; 1) Mettawee facies. Purple and green slate, mudstone, and phyllite; this facies constitutes the bulk of the formation. 2) North Brittain conglomerate member. An intraformational limestone-pebble, slate-matrix conglomerate. 3) Mudd Pond member. A thin but persistent orthoquartzite. 4) Zion Hill member. A discontinuous graywacke or sub-graywacke unit ranging from a pebble conglomerate to mudstone. 5) Bomoseen member. A massive, olive-drab, medium-grained graywacke.

Biddie Knob formation: a chloritoid-bearing purple and green slate and phyllite with minor beds of limestone and quartzite. Lower Cambrian(?).

The sense of the Lower Cambrian succession is given by load casting and graded bedding in the Zion Hill, and in rare arkoses mapped with the Bomoseen. The sense of succession in the Mount Hamilton group is given by cross-bedding, graded bedding, and by channel filling.

Structurally, the Taconic sequence consists of nested thrust slices subsequently folded together. Although each slice has its own characteristic stratigraphy and structure, correlation of the units, down to the formational level, presents little difficulty. The structure is typified by the Giddings Brook recumbent bottoming fold in the area between the Taconic Range and Lake Bomoseen. The fold is at least 5 mi. in amplitude, the movement was E. to W., and the axial plane is nearly horizontal. Digitations on this major structure explain the map pattern. Key units of the Taconic sequence have been recognized E. of the Taconic Range; the E. flank of the Range is now underlain by an inverted sequence of Lower Cambrian rocks.

The Sudbury nappe at the N. end of the map area is composed of the Lower Ordovician Chipman formation. The structure does not root in the E. limb of the Middlebury synclinorium as reported by Cady, but is a thrust slice, whose SE. edge tucks under the Taconic sequence. Structurally, this unit is part of the latter.

The Whipple marble at the N. end of Whipple Hollow is part of the Lower Ordovician Bascom formation, which in this area has been moved westward over the younger black phyllite through a recumbent fold involuted into the Taconic sequence. This structure indicates the perisistence of intense deformation after the development of the Taconic structure.

Topologically, the Taconic sequence is in the southward continuation of the Middlebury synclinorium. Coupled with the discovery of the inverted Lower Cambrian rocks E. of the Taconic skyline, the evidence supports an allochthonous origin of the Taconic sequence. The gradational contact between the green and black phyllites E. of the Taconic Range, and the presence in the black phyllite of beds characteristic of the Taconic sequence show that part of the black phyllite here is allochthonous.

The thrusting is dated as late Trenton on the basis of exotic blocks of Taconic rocks in an autochthonous black slate at Forbes Hill. Similar rocks have also been found elsewhere at the periphery of the Taconic sequence. The thrusting may have occurred as submarine gravity slides of soft rocks; slump structure is indeed abundant in the Taconic sequence. The intimate mixing of the black slates of the Taconic sequence and of the Trenton mud may make the mapping of the Taconic fault unfeasible even in principle. Continued deposition of black mud after the emplacement of the Taconic nappes could account for the reported Trenton unconformity at the margin of the Taconic sequence S. of the Castleton area.

The Taconic sequence probably was deposited in the area of the present Green Mountains. The upper part of the Mount Hamilton group correlates by fossils with the Moretown-Cram Hill formations of eastern Vermont. The Mount Hamilton group is free of volcanic rocks and is thin, in contrast with the Moretown-Cram Hill formations; this change is consistent with paleogeographical requirements, as the Cambro-Ordovician, typically eugeosynclinal deposits of eastern Vermont, must somehow change into the synchronous, but typically miogeosynclinal deposits of western Vermont and eastern New York. --Auth.

3-1765. Strand, Trygve. THE SCANDINAVIAN CALEDONIDES, A REVIEW: Am. Jour. Sci., v. 259, no. 3, p. 161-172, 2 figs., March 1961, 7 refs.

A short digest of the geology of the Caledonides which form the western part of the Scandinavian peninsula, the greater part on Norwegian territory. The eastern Caledonian margin is formed by a range of nappes overthrust upon autochthonous Cambro-Ordovician sediments, which in turn rest upon the peneplaned surface of the Precambrian rocks of the Baltic shield. Between 61°40' and 68°20'N. the eastern part of the chain is on Swedish territory, a strip of land more than 800 km. long and with a mean width of about 100 km. Between 68°30' and 69°N. again a narrow marginal strip is partly on Swedish and partly on Finnish territory. There is no western border of the Scandinavian Caledonides; the rocks that disappear beneath the sea along the W. and N. coast belong to central parts of the orogenic belt.

Discussed in turn are stratigraphy, the Caledonide nappes, basal gneisses and basal massifs, age of deformation.

The Scandinavian Caledonides have all the attributes of a fully developed orogenic belt: strong volcanism occurred in the geosynclinal phase, large sheets of sediments and even of the underlying basement were cut out and moved as nappes for distances of 200 km. or perhaps even more, and plutonic processes led to magmatism and strong metamorphism and migmatization. Probably no other part of the world shows a stronger manifestation of Caledonian orogeny. Perhaps as a consequence of this, the later history of Scandinavia is mainly one of vertical uplift and fracturing (exception being made for some marginal districts). This is in contrast to the Caledonian regions in the British Isles and in Spitzbergen, which show a rich history of late Paleozoic and younger subsidence and sedimentation.--From auth., p. 161, 172.

3-1766. LeRoy, Leslie Walter. LUNAR FEATURES AND LUNAR PROBLEMS: Geol. Soc. America, Bull., v. 72, no. 4, p. 591-603, 2 illus., 9 figs., Apr. 1961, 17 refs.

The major features of the Moon (mares, highlands, craters, fractures) are briefly reviewed to encourage geologists to participate in the solution of lunar problems - problems involving the interpretation of varied land forms, the rock types and their distribution, potential ore deposits, and lunar tectonics. Special attention is given the fracture systems, the origin of the lava filling many closed craters, and the origin of the central peak complexes.--Auth.

2. GEOMORPHOLOGY

See also: Stratigraphy 3-1826; Geochemistry 3-1902; Fuels 3-2049.

3-1767. Snell, Joan B. METHOD FOR PREDICTING LINE-OF-SIGHT CAPABILITIES: PRELIMINARY INVESTIGATIONS: Geol. Soc. America, Bull., v. 72, no. 3, p. 479-484, 3 figs., table, March 1961.

A mathematical terrain model, from which it is possible to predict the number of valleys visible from the highest elevation within an area, has been applied to the New England physiographic province and to an area in the Colorado Plateau. Correlation between the predicted and actual number of visible valleys for 2 areas is good.--Auth.

3-1768. Bowen, Robert. PALEOTEMPERATURE ANALYSES OF MESOZOIC BELEMNOIDEA FROM GERMANY AND POLAND: Jour. Geology, v. 69, no. 1, p. 75-83, 2 figs., table, Jan. 1961, 19 refs.

Specimens of Jurassic and Cretaceous Belemnoidea were analyzed and their paleotemperature record compiled from mass-spectrometric measurements. The data are compared with information assembled from other fields of investigation. It is demonstrated that from a subtropical climate in the later Jurassic, a more diversified one developed in the Cretaceous. From the rather cool conditions of the Neocomian, a temperature climax was reached in Albian times - to be followed by a decline attaining its minimum in Cenomanian waters. Later, another temperature climax occurred - in the Coniacian-Santonian. Subsequently, a gradual lowering of temperature took place during the Campanian and was succeeded by cool, stable conditions in the Maestrichtian. This picture of Cretaceous climatic change was derived from the analyses of Mesozoic material from Germany and Poland, described in detail in the present paper and supplemented by examination of additional specimens from western Europe. It is possible that the late Cretaceous temperature decline was instrumental in the extinction of the poikilothermous dinosaurs. It is apparent that the pole shifted in relation to Europe during the Mesozoic, but its position is not yet determined.--Auth.

3-1769. Richards, Leverett G. ICE AGE COMING?: 128 p., illus., New York, John Day, 1960.

A popular summary of what is known about the earth's ice: the ice ages of the past and the possible future, the glaciers of today, the icebergs that "calve" from them, the ice caps of Antarctica and Greenland, the vehicles and instruments of the glaciologist, and the oddities that ice exhibits in great masses and extreme conditions.--M. Russell.

3-1770. Leighton, Morris M., and John A. Brophy. ILLINOIAN GLACIATION IN ILLINOIS: Jour. Geology, v. 69, no. 1, p. 1-31, 14 figs., 2 pls., table, Jan. 1961, 37 refs.

Present knowledge of the Illinoian glaciation in Illinois supports the following interpretations: 1) the invading Illinoian glacier was one of great vigor; 2) its limit was determined by a change in its climatic controls which halted its advance and initiated the retreat of its margin, during which moderately thick submarginal drift was deposited but no continuous terminal moraine or recessional moraines were built; 3) NE.-SW.-trending ridges of the Kaskaskia River basin are stagnation features, recording the fact that the glacial margin had retreated little more than 25 mi. before the glacier became stagnant; 4) many crevasse fillings were made, and after some crevasses, both longitudinal and frontal, had reached through the ice, eroding streams confined along them cut straight shallow depressions, some of them crossing divides and forming trellis drainage; 5) numerous beautiful conical and ellipsoidal moulin kames, some compound and mammoth in bulk, were made helter-skelter along and between crevasse fillings as the glacial ice became decadent; 6) the small Mendon recessional moraine on the higher Galesburg Plain N. of Illinois River records a somewhat longer glacial activity for a brief time, but its construction was soon followed by stagnancy when crevasse traces were eroded on flat surfaces back of it, causing many of the present linear lines of drainage; 7) the Buffalo Hart moraine, continuous N. of Illinois River for but little more than 60 mi. records a brief time of renewed snowfall and glacial activity; 8) the Illinoian glacial lobe at its maximum development had the full deployment suggested by Leverett as covering northwestern Illinois at the time that it reached southeastern Iowa and its maximum limit in southern Illinois; 9) the dominant dolomitic bedrock of the northern counties and the greater relief of the region provided conditions for different physical and geochemical weathering than those of the coal measures area to the S.; 10) the glacier was as vigorous when it transgressed the northern area as it was elsewhere, and it became stagnant when the rest of the glacial lobe became stagnant; 11) during the Sangamon interglacial interval, weathering and erosion modified the Illinoian drift everywhere, the profiles of weathering assuming characteristics according to the physical and chemical conditions; 12) no loess was deposited anywhere on the Illinoian drift because there were no valley trains during the wasting-away of the glacier, the glacier melting down in place; 13) the only loess deposit genetically connected with the Illinoian glaciation is the pro-Illinoian Loveland loess that is found over wide areas beneath and beyond the Illinoian drift; 14) Farmdale loess and the superjacent Peorian loess (Iowan and Tazewell) form a widespread mantle over the weathered Illinoian and other deposits of much of the midwest.--Auth.

3-1771. Ruxton, Bryan P., and Leonard Berry. NOTES ON FACETED SLOPES, ROCK FANS AND DOMES ON GRANITE IN THE EAST-CENTRAL SUDAN: Am. Jour. Sci., v. 259, no. 3, p. 194-206, 9 figs., 2 pls., March 1961, 30 refs.

Although most of the residual hill masses in the E.-central Sudan show fringing pediments separated by a sharp angular break from the hillslopes, many also show several additional small facets of slope parallel with the contours. When stripped of weathered debris, such faceted slopes reveal plane and convex sheets or lenses of granite separated by steeply dipping joints. Rock fans with sheeting parallel to their surfaces are recorded on both the fringing pediments and the lower hillslopes.

Mantled cone-shaped hills with straight side slopes appear to be modified to a dome form when stripped of their rock waste. Some domes retain concave and straight slope units on their sides whereas others become convexly faceted.

The production of faceted hillslopes, rock fans, and faceted domes on a homogeneous massive rock is believed to be due to unloading. Although if unloading occurs it will be a universal factor, its effect will be most clearly revealed when denudation is weak and slow in a stable area on hard elastic massive rocks. --Auth.

3-1772. Menard, Henry W. SOME RATES OF REGIONAL EROSION: Jour. Geology, v. 69, no. 2, p. 154-161, 2 tables, March 1961, 21 refs.

Past and present rates of regional erosion are calculated for the Appalachian, Mississippi, and Himalayan regions. The present rate of erosion of the Mississippi region is about the same as the average rate during the last 150X10^6 years. The average rate of erosion of the Appalachian region during the last 125X10^6 years is 7. 8 times as fast as at present. The average rate of erosion of the Himalaya region during the past 40X10^6 years is only 0.02 of the present rate. The fastest average rate observed is about 20 cm/10^3 years, obtained in the Himalaya region for the past 40X10^6 years and also in the Rocky Mountain region for the 40 X 10^6 years of Upper Cretaceous time.

The proportion of sediment permanently lost from the continents to abyssal plains is: Appalachian region, 17%; Mississippi region, 8%; and Himalaya region, possibly 49%. Losses of these magnitudes cannot have occurred during much of the geological past.--Auth.

3-1773. Melton, Mark A. THE EFFECT OF SEDIMENT TYPE OF THE SHAPE AND STRATIFICATION OF SOME MODERN FLUVIAL DEPOSITS: Am. Jour. Sci., v. 259, no. 3, p. 231-233, fig., 2 tables, March 1961, ref.; Reply, by Stanley A. Schumm, p. 234-239, fig., 11 refs.

Discussion of GeoScience Abstracts 2-848.

3-1774. Brush, Lucien M., Jr. DRAINAGE BASINS, CHANNELS, AND FLOW CHARACTERISTICS OF SELECTED STREAMS IN CENTRAL PENNSYLVANIA: U.S. Geol. Survey, Prof. Paper 282-F, p. 145-180, 23 figs., 4 pls. (3 in pocket, incl. geol. map, scale 1 in. to 6 mi.), 9 tables, 1961, 41 refs.

The hydraulic, basin, and geologic characteristics of 16 selected streams in central Pennsylvania were measured for the purpose of studying the relations among these general characteristics and their process of development. The basic parameters which were measured include bankfull width and depth, channel slope, bed material size and shape, length of stream from drainage divide, and size of drainage area. The kinds of bedrock over which the streams flow were noted.

The basins were studied by examining the relations of drainage area, discharge, and length of stream from drainage divide. For the streams investigated, excellent correlations were found to exist between drainage area and the 2.3-year flood, as well as between length of stream from the basin divide and drainage area. From these correlations it is possible to predict the discharge for the 2.3-year flood at any arbitrary point along the length of the stream.

The long, intermediate, and short axes of pebbles sampled from the bed of the stream were recorded to study both size and sphericity changes along individual streams and among the streams studied. No systematic downstream changes in sphericity were found.

Particle size changes are erratic and show no consistent relation to channel slope. Particle size decreases downstream in many streams but remains constant or increases in others. Addition of material by tributaries is one factor affecting particle size and another is the parent material. Wear does not appear to account for some of the changes noted in particle size in a downstream direction. Comparison with laboratory studies indicates that at least in some streams the downstream decrease in size is much greater than would be expected from wear alone.

The type of bedrock underlying the channels included in this study appears to affect both channel slope and particle size. For a given length of stream, a stream channel underlain by sandstone tends to have a steeper slope and larger bed material than channels underlain by shale or limestone. Hence, a stream which heads in sandstone and ends in limestone tends to have a more rapid decrease in slope and particle size than a stream heading in limestone and ending in sandstone. The association of steep slopes and small particles for limestone channels implies that slope and particle size may show a vague correlation between lithologic groups, although no correlation may exist within a given lithologic type.

In addition to the effect of bedrock on slope and particle size, there is some evidence that channels in limestone or dolomite have a slightly smaller cross section at bankfull stage than channels in shale or sandstone.

Near the headwaters of many of these streams, a deposit of periglacial rubble affects the slope and bed material size. Some of the debris contains residual boulders which are too large to be moved by ordinary floods and, therefore, impose larger particle sizes in the bed of the stream. The addition of this very coarse debris to the bed material is another example of the influence of geologic factors on stream channels even though the channel consists of unconsolidated debris instead of bedrock.

The influence of geologic factors noted in selected streams in central Pennsylvania may be directly applicable to areas other than the Appalachian Mountains, but the general process is no doubt similar in most areas. In large alluvial valleys bedrock cannot be much of an influencing factor, yet large, thick alluvial deposits and terraces are in a sense "bedrock" materials upon which the stream works to form the landscape.--From auth.

3-1775. Moss, John H., and William E. Bonini. SEISMIC EVIDENCE SUPPORTING A NEW INTERPRETATION OF THE CODY TERRACE NEAR CODY, WYOMING: Geol. Soc. America, Bull., v. 72, no. 4, p. 547-555, illus., 3 figs., table, Apr. 1961, 11 refs.

Seismic studies of the Cody terrace complex bordering the Shoshone River near Cody, Wyoming, disclose: 1) no relationship between surficial terrace form and underlying bedrock topography; 2) irregular bedrock topography with relief up to 50 ft.; 3) thickness of gravel and silt overlying bedrock averaging about 60 ft. and reaching a maximum of more than 100 ft. These data suggest that the Cody terrace is an alluvial terrace, not a rock-cut terrace as previously postulated.

Although interrupted by the Shoshone canyon, the gravel in the Cody terrace is believed to be the correlative of the gravel in the lower terrace complex in the South Fork valley which is traceable into valley-train deposits fronting the moraine at Ishawooa. The Cody gravel is therefore in part glaciofluvial.

The Cody terrace was probably formed in 3 stages

1) cutting of the broad bedrock floor beneath the gravel during a period of lateral cutting and slow downcutting from the Powell surface; 2) deposition of a gravel fill to the height of the highest Cody bench during a period of aggradation associated with advance of glaciers in the upper Shoshone Valley; 3) cutting of the benches of the Cody terrace in the fill by lateral planation and slow downcutting during and after retreat of the ice from the Shoshone drainage area.

These results underscore the usefulness of seismic studies in geomorphic work.--Auth.

3-1776. **Lunev, B.S. THE MOST RECENT TECTONIC MOVEMENTS AS REFLECTED IN THE STRUCTURE OF THE MIDDLE KAMA TERRACES: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 7, p. 84-87, pub. 1961, 15 refs.**

In a study of Quaternary tectonic activity and terraces the following conclusions were reached: 1) thickness of Quaternary alluvium decreases in regions of the development of positive structures, and the granulometry of the gravel-sand deposits depends on the contemporary tectonic movements; 2) the bedrock base of terraces rises toward crests of positive structures; 3) width of the Kama river valley decreases when the river intersects an anticline and increases when a syncline or a monocline is intersected; 4) in certain cases, a sharp bending of the river valley is observed when a positive structure is intersected.--From LC.

3-1777. **Norris, Robert M., and Kenneth S. Norris. ALGODONES DUNES OF SOUTHEASTERN CALIFORNIA: Geol. Soc. America, Bull., v. 72, no. 4, p. 605-619, 8 illus., 2 figs., 2 tables, Apr. 1961, 44 refs.**

The Algodones dune belt, which is 40 mi. long in a northwesterly direction, 3-6 mi. wide, and has individual dunes 200-300 ft. high, lies along the southeastern border of the Cahuilla basin, a structural depression in southeastern California. Much of the basin is below sea level and includes Imperial and Coachella valleys. The lowest portion of the basin is now occupied by the Salton Sea.

Most detritus enters the basin from the high mountains to the W. and NW.; little material is contributed by the lower, drier desert ranges to the E.

The dunes appear unsystematic from the ground, but as seen from the air they consist of long NW.-trending ridges on the W. which individually curve eastward and disappear in a complex of prominent S.-facing slip faces. In the central and southern part of the dune area some of the slip faces are 200-300 ft. high and overlook large flat-floored, sand-free depressions which are interpreted as exposed parts of the desert floor over which a succession of large, closely spaced complex barchans is advancing. Present conditions favor destruction of the depressions by encroachment of sand in the form of small linear ridges and barchan dunes from the transverse dunes.

Color and degree of rounding of the sand grains indicate that the dunes are now less active than in the past and that the amount of sand is not increasing significantly.

The dunes were probably produced by wind transport of sand inshore from the beaches of Lake Cahuilla, a much larger forerunner of the Salton Sea. The large volume of material in these ancient beaches indicates vigorous wave and current action along the northeastern shore of the lake.--Auth.

3-1778. **Reynolds, Doris L. LAPIÉS AND SOLUTION PITS IN OLIVINE-DOLERITE SILLS AT SLIEVE GULLION, NORTHERN IRELAND: Jour. Geology, v. 69, no. 1, p. 110-117, 3 figs., pl., Jan. 1961, 25 refs.**

Evidence is presented to show that deep flutings and cavernous forms, occurring on essentially vertical joint planes of olivine-dolerite sills on Slieve Gullion, resemble the lapiés of Hawaii and New Zealand. They have been formed in a similar way, that is, as a result of chemical erosion of basaltic rock by surface waters escaping down the joint planes of essentially impervious layers. Occasionally the lapiés intersect vertical sheetlike veins of microgranite, which, on account of their greater resistance to erosion, remain like partitions up the middle of lapiés. A hypothesis that the microgranite was intruded while the dolerite was still fluid has been based on the erroneous suppositions a) that the lapiés were originally occupied by microgranite with a pipelike form and b) that this form is inconsistent with the microgranite having been emplaced in solid dolerite. Structural criteria are therefore established by reference to which it can be discovered whether microgranite, irrespective of whether it occurs as sheetform veins or as pipes, was emplaced a) in molten or rheid dolerite or b) in crystalline and rigid dolerite. --Auth.

3-1779. **Keller, Walter D. MINERAL AND CHEMICAL ALLUVIATION IN A UNIQUE PEDOLOGIC EXAMPLE: Jour. Sed. Petrology, v. 31, no. 1, p. 80-86, 2 figs., 2 tables, March 1961, 5 refs.**

Flood water from the Snoqualmie River and Cherry Creek, laden with fine silt, colloidal clay, and dissolved ions, stands quietly part of each winter season over land underlain by an old peat bog near Duvall, Washington. This water, instead of leaching and abstracting inorganic plant nutrients as is the usual role of surface water and soil, donates to the soil dissolved ions, colloidal material, and fine-grained, partially decomposed rock fragments (naturally pulverized agstone). Analyses are presented which indicate the annual contribution of the alluviation.

In the chemical weathering of rocks to soil the sequence of energy effects begins first with the disruption of relatively strong crystal bonds between ions, thereby making the ions vulnerable to pick up by plants by way of the exchange bonding energy of rootlets. As weathering advances, however, and abstraction of ions from the rocks by leaching continues, the concentration (activities) of available nutrient ions in the soil decreases, and their energies of exchange from soil clay rises above the energy of the rootlets to pull them away. Thus, weathering at this later stage is destructive to soil. Agriculture, therefore, operates most efficiently on soil in which the rocks are in a stage of partial or intermediate decomposition.

Economic geologists interested in the sources, use, and production of agstone may apply in practice the principles which may be deduced from this example in nature.--Auth.

3-1780. **Tanner, William F. OFFSHORE SHOALS IN AREA OF ENERGY DEFICIT: Jour. Sed. Petrology, v. 31, no. 1, p. 87-95, 7 figs., March 1961, 19 refs.**

The coastal energy level off the Apalachicola River delta (panhandle coast of Florida) appears to be adequate to handle approximately $2X10^4m^3$ of sand and coarse silt per year. The river, through much of its recent history, has probably been delivering approximately $5X10^5m^3$ of bed load per year. Over a 5,000 year period, this projects to an excess of approximately $2.5X10^9m^3$. The beach ridges, barrier islands, and furrowed offshore shoals in the area may have been formed as severe storm waves redistributed this load. The amount of sand stored in these geomorphic features is estimated to be approximately equal to the projected 5,000-year excess.

An energy-vs-load chart is presented as an aid in the evaluation of coastal features.--Auth.

3-1781. Melton, Mark A. ORIGIN OF THE DRAINAGE OF SOUTHEASTERN ARIZONA: Arizona Geol. Soc., Digest, v. 3, p. 113-122, 3 figs., 1960, 8 refs.

The drainage history of desert basins does not necessarily begin with uplift of mountains and formation of undrained basins. In the Safford Valley, Graham County, a preexisting drainage system was able to maintain itself throughout the mountain-building epoch and was disrupted, not by diastrophism, but much later by capture by structurally favored tributaries. Desert basin fills are not necessarily entirely the product of erosion of the bounding mountain ranges. At times, erosion in the mountains is sufficiently slow to allow rivers to import fine-grained material and deposit it next to the mountain front. The cause of deposition of the "lake sediments" in the Safford Valley was related to the accidental coincidence of the mouth of the major drainage with a center of volcanism that raised the base level of the entire system.--From auth. concl.

3-1782. White, Everett M. DRAINAGE ALIGNMENT IN WESTERN SOUTH DAKOTA: Am. Jour. Sci., v. 259, no. 3, p. 207-210, pl., March 1961, 5 refs.

NW.-SE. stream alignment in western South Dakota coincides with the prevailing wind direction. This alignment appears to be due to the periodic accumulation of locally derived eolian sediments in drains which are not aligned. Because of this deposition, unaligned drains are not elongated by water erosion as rapidly as those which are aligned. Eolian sediment can be derived locally and deposited when the prairie vegetation is destroyed by fire or weakened by drought.--Auth.

3-1783. Hack, John T., and John C. Goodlett. GEOMORPHOLOGY AND FOREST ECOLOGY OF A MOUNTAIN REGION IN THE CENTRAL APPALACHIANS: U.S. Geol. Survey, Prof. Paper 347, 66 p., 31 figs., 7 pls. incl. map (in pocket), 16 tables, 1960, 65 refs.

The area studied, mostly in the headwaters of the Shenandoah River, Augusta and Rockingham counties, Virginia, includes about 55 sq. mi. of densely forested mountain land and has an average relief of about 1,500 ft. It is part of an area that in June 1949 was subjected to a violent cloudburst which damaged large tracts on slopes and bottom lands. Most of the area is underlain by flaggy arkosic sandstone and interbedded reddish shale of the Hampshire formation of Devonian age. The highest ridges are capped by massive sandstone of the Pocono formation of Mississippian age. In most of the area the rocks dip gently to the SE. but in the northwestern and southeastern parts they are folded into synclines that localize northeastward-trending ridges.

Topography is remarkably uniform, and the slopes are graded to regular forms that may be described in simple mathematical terms. Because of a high bifurcation ratio between streams of different orders, almost half of the area is composed of first-order valleys. Each of the first-order valleys may be subdivided into 5 different parts based on the convexity or concavity of the contours. Each part, because of its geometric form, receives water downslope at a different rate. The driest area on which the contours are convex outward (from the mountain) is called the "nose" and presumably receives the least moisture by flow from the slope above. The side slope has straight contours and hypothetically receives somewhat greater runoff. The hollow above the stream head is an area of concentration of the drainage lines in which the discharge of storm runoff is inferred to increase downslope at a rate greater than the square of the distance. It merges with the channelway, a narrow strip running down the valley axis between steep side slopes. In the channelway, runoff increases downstream in proportion to the 1.6 power of the distance. The channelway at some places is bordered by a narrow strip of concave-upward slope that because of its geometric form receives somewhat more runoff than the side slopes above. In valleys larger than the first and second order the channelway is so broad that the stream channel itself is bordered by bottom lands many times larger. All of the bottom lands are subject to erosion or deposition during floods of various frequencies.

The stony and bouldery soils of the mountain slopes were sampled at many localities by measuring the diameters of individual particles selected at points on a grid pattern. The mean size of the particles on the surface of the ground was found to vary markedly from one part of a valley to another and to increase roughly with the runoff concentration inferred from the topography. The texture of debris is fine on noses and coarse in channelways and hollows. Mean size ranges from less than 1 mm. on some noses to over 250 mm. in some hollows. In the channelway the size generally decreases to about 100 mm. and remains nearly constant in a downstream direction. Standard deviation or sorting of the particles narrows as drainage area increases.

Fields of large, angular quartzite blocks are conspicuous features of some side slopes and noses. They generally are present where massive quartzitic sandstone of the Pocono formation crops out in an exposed location such as a ridge top or nose, and where the sandstone is underlain by relatively soft shale. In these places boulders have slid down, forming a mantle on the slope below.

The vegetation of the area includes about 45 species of trees, 25 of which are closely related in their local distribution to moisture conditions. Concentration of runoff related to topographic forms is a particularly important factor. The close relation between the vegetation, the landforms, and the texture of the soil mantle is shown by the analysis of sample plots in 7 first-order valleys, on several ridges, and on the flood plain of the Little River. Vegetation was further studied by the preparation of a forest map on which the vegetation is classed in 3 units based on the presence or absence of a few species. Unit 1, the northern hardwood forest, defined by the presence of yellow birch, basswood, and sugar-maple, or any one of the 3, occupies moist environments such as hollows and bottomlands.

Unit 2, the yellow pine forest, defined by the presence of pitch-pine and table-mountain pine, or either one of the 2, and by the absence of the species that define unit 1, occupies relatively dry sites such as ridges and noses. Unit 3, the oak forest, defined by the absence of all of the above species, occupies intermediate sites, especially side slopes. Each of the 3 forest types contains many other characteristic species, especially oaks that are also affected by topographic position.

The ground cover of shrubs and herbaceous plants varies in composition in a manner similar to that of the trees. The form of the forest also changes in relation to topography and moisture, for the trees grow larger and taller in the hollows than on noses and side slopes. The distribution of the 3 forest types is thought to coincide with the duration of moisture in the ground through the growing season. Environmental factors that affect moisture directly also affect the physiological processes of the plants. The relation is both direct and indirect, and no cause and effect relation between moisture regimen and species distribution is implied. Topographic position on the slope is an important factor in the moisture regimen, but so also are geologic structure, soil texture, exposure, and altitude.

The violent cloudburst flood of June 1949 that caused severe erosion in the Little River valley afforded an opportunity to study the importance of extremely low frequency floods as agents of erosion and as factors in forest ecology. During this storm, which probably lasted only a few hours, rainfall in excess of 9 in. fell on an area centered over Buck Mountain. The runoff produced dozens of debris avalanches on the upper mountain slopes, enlarged most of the channelways, and reworked the debris on the bottom lands of many larger valleys and in places removed the forest cover on the entire valley floor. The high rates were effective in eroding mountain slopes, sorting surficial debris, transporting debris, and producing terraces, alluvial fans, and cones. It is believed that such floods, though rare, occur frequently enough to exceed in importance, as erosive agents, all intervening lesser floods that do not damage the forest. The floods are also an important element in the life history of the forest; they provide open spaces for the growth of trees that require open sky, thus keeping the species composition in a state of flux.

A special study was made of asymmetric topographic forms in the area. Mountain slopes on the average are steeper facing the NE. and SE. quadrants. Asymmetry of the slopes is accompanied by differences in soil texture and vegetation. The differences are believed to be due to moisture conditions as determined by geologic structure and by exposure. In drainage areas of similar size the steeper slopes correlate with the finer textured soils and the more open forest floor that are characteristic of the northern hardwood forest type.

Inasmuch as the present topography and distribution of the vegetation can be understood in terms of observable processes active today or in the recent past, neither peneplanation nor progressive biological succession need be called upon in order to explain their characteristics. On the contrary, the regularity of the forms and their close relation to the geology and vegetation argue in favor of more uniformitarian concepts.--Auth.

3. STRUCTURAL GEOLOGY

See also: Areal and Regional Geology 3-1757, 3-1762; Geomorphology 3-1776; Geophysics 3-1875; Sedimentary Petrology 3-1981.

3-1784. McBirney, A.R., and Myron G. Best. EXPERIMENTAL DEFORMATION OF VISCOUS LAYERS IN OBLIQUE STRESS FIELDS: Geol. Soc. America, Bull., v. 72, no. 3, p. 495-498, 6 illus., 2 figs., table, March 1961, 6 refs.

Alternating layers of soft viscous wax and asphalt were squeezed in various orientations within a constant-strain squeeze box. Compression produced folds and small wrinkles whose axial orientation is determined solely by the intersection of the plane normal to the direction of maximum shortening with the layer surface. Formation of folds in viscous materials appears to be a function of the strain rate. --Auth.

3-1785. Lukyanov, A.V. PLASTIC DEFORMATIONS IN LIMESTONES FROM ZONES OF SHATTERING ACCOMPANYING MAJOR FAULTS: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 4, p. 82-85, 4 figs., pub. 1960.

The following conclusions are drawn from data on the structure and relationship of limestone pebbles in nondeformed and deformed pebbles:

1) Stresses in the shattered zone were sufficient to cause plastic deformations in limestone, under the temperature, chemical, and other conditions prevailing there.

2) Under those conditions, the limestone deformation was expressed in compression in one direction, and in spreading in 2 other directions, normal to the first. The limestone flowed as a plastic mass under a one-sided pressure. In the process it developed schistosity normal to the compressing stresses; its texture, however, changed but little.

3) The pebbles have been thinned 4 to 5 times, in the direction of the stress, and have been elongated correspondingly, 2 to 2.2 times, in 2 directions normal to it.

It is concluded that both small and large limestone bodies undergo plastic deformation when subjected to powerful stresses originating in the process of formation of major faults.--From auth., p. 84, 85.

3-1786. Delitsin, I.S., and Yu. A. Rozanov. EXPERIMENTAL DATA ON PLASTIC DEFORMATIONS IN QUARTZITE: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 7, p. 87-92, 4 figs., pub. 1961, 5 refs.

D. Griggs, J. Bell and P.W. Bridgeman showed that brittle deformation is characteristic of quartz under conditions of high confining pressure. Experiments by E.V. Tsinzerling and A.V. Shubnikov showed that a plastic deformation of quartz can occur under certain conditions of temperature, pressure, and solution. A small, cylindrical, 24-26 mm. long and 15 mm. diameter, piece of intensely deformed quartzite was soaked for 7 days in an alkaline solution, then placed in a special steel cylinder, heated to 200°, and submitted to a pressure of about 1,600 kg./sq. cm. After the experiment, an examination of the sample showed the following: it was slightly shorter (from 25.5 mm. to 25.2); the quartz grains became bright and transparent, their dimensions increased by 1.5 to 2 times, and they were slightly bent. The formation of Dauphiné twins was also observed in diopside grains of the sample. The formation of these twins and the bending of the quartz grains proves that at least the first stage of plastic deformation was reached.--From LC.

3-1787. Muehlberger, William R. CONJUGATE JOINT SETS OF SMALL DIHEDRAL ANGLE: Jour. Geology, v. 69, no. 2, p. 211-219, 4 figs., pl., March 1961, 21 refs.

The Coulomb law of the Mohr theory of failure predicts a constant dihedral angle between conjugate failure planes regardless of the magnitude of the stress difference required for failure. The maximum principal stress bisects this angle. Experimental studies show that this angle actually becomes smaller as confining pressure is decreased. For low pressures, Nadai, enlarging on a suggestion by Leon, proposed a curved Mohr envelope which would intersect the normal stress axis at a right angle. If so, there could then be a critical stress circle tangent to the envelope only at the apex. The single plane of failure, lying parallel to the maximum principal stress, is a tension joint in the usual terminology (extension fracture). A slight increase in stress difference will move the critical circle off the apex, and it will then intersect the envelope at 2 points; the resulting conjugate fractures will enclose a small dihedral angle. Within a small range of increasing stress differences, the angle will increase to the usual angles for shear failure (about 60^{o}).

At least two field examples indicate that Nadai's proposals are correct. Parker's joint study in New York demonstrated a conjugate shear set with angles ranging from 0 to 20^{o}. These joints have plumose surfaces that may be indicative of extension fractures. Similar jointing has been observed in western Pennsylvania and eastern Ohio, as studies by Nickelsen and Hough and by Ver Steeg indicate. Duschatko's studies along the Lucero uplift, New Mexico, show a single joint set being replaced along strike by a conjugate joint set with dihedral angle increasing up to 65^{o}. This type of fracturing appears to be present in the Bighorn and Beartooth mountains as well. --Auth.

3-1788. Harrison, Jack E., and Robert H. Moench. JOINTS IN PRECAMBRIAN ROCKS, CENTRAL CITY - IDAHO SPRINGS AREA, COLORADO: U.S. Geol. Survey, Prof. Paper 374-B, p. B1-B14, 2 maps, 8 diags., table, 1961, 13 refs.

Attitudes of about 9,000 joints in Precambrian intrusive and metasedimentary rocks in the 50-sq-mi. area studied reveal that some joints sets are systematically distributed. Each of the principal Precambrian intrusive masses contains primary joints. Joints related to folds have formed during 2 periods of Precambrian deformation and probably during Laramide (Late Cretaceous and early Tertiary) arching of the Front Range.

A time sequence of geologic events and jointing can be worked out as follows: First, granodiorite was intruded during the older Precambrian deformation; primary joints formed in the granodiorite, and joints related to sinuous and doubly plunging folds formed in the metasedimentary rocks. Second, biotite-muscovite granite was intruded late in an older period of Precambrian deformation; primary joints formed in the granite. Third, Precambrian metamorphic and igneous rocks were locally deformed during a younger period of Precambrian folding; joints related to this folding formed in all Precambrian rocks, and a unique set of slickensided joints formed predominantly in the more massive granitic rocks. Fourth, a system of 4 joint sets was formed that locally cuts Precambrian rocks but not the Tertiary rocks that intrude them. Joints of this system were locally followed by Tertiary dikes, and therefore can be dated in outcrop only as post-Precambrian but pre-Tertiary. The conformity of the system with that expected from arching of the Front Range highland leads us to conclude that the post-Precambrian system probably is Laramide in age.--Auth.

3-1789. McKinstry, Hugh E. STRUCTURE OF THE GLENARM SERIES IN CHESTER COUNTY, PENNSYLVANIA: Geol. Soc. America, Bull., v. 72, no. 4, p. 557-577, 14 figs., pl., Apr. 1961, 38 refs.

The rocks of the Glenarm series in southeastern Pennsylvania, of probable Paleozoic age, show strongly overturned and locally recumbent folds. Detailed mapping of structural features indicates that not only the bedding but also the cleavage and axial planes of folds have undergone deformation which increases in intensity from NW. to SE. along with increasing grade of metamorphism. These observations, together with the outcrop pattern, point to large-scale refolding of earlier folds; recumbent structures result from the warping of axial planes that originally had steeper dips. This structure accords with the pattern of folding of unquestioned Paleozoic rocks in the adjoining Philadelphia area without recourse to the hypothetical "Martic overthrust."

The writer suggests that the late-stage deformation is related mechanically to the change in strike of the Appalachian belt; the belt strikes generally N.-S. in New England and Virginia but is nearly E.-W. in Pennsylvania.--Auth.

3-1790. Kizevalter, D.S., and M.V. Muratov. LENGTHY DEVELOPMENT OF GEOSYNCLINAL FOLDED STRUCTURES IN THE EASTERN PART OF THE CRIMEAN MOUNTAINS: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 5, p. 12-27, 12 figs., pub. 1960, 13 refs.

The author shows, using the structures of the eastern part of the Crimean mountains as an example, that a protracted fold formation is the basic process in folded structure formation. Phases of folding, showing nonconformity, are not connected with folding processes but are the result of either elevation or sinking of the earth's crust. The Sudak synclinorium is composed of a continuous complex of deposits from Bathonian to Tithonian. The E. Crimean synclinorium was formed by continuous folding from Kimmeridgian to Paleogene.--From LC.

3-1791. Suvorov, A.I. MESOZOIC AND CENOZOIC BLOCK-FOLDED STRUCTURES OF THE NORTHERN TIEN SHAN: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 4, p. 48-63, 3 figs., 2 tables, pub. 1960, 36 refs.

In the character of its Mesozoic and Cenozoic structure, Tien Shan cannot be assigned to either folded, geosynclinal, or platform conditions. Northern Tien Shan can be defined as a province of a special type of structure and development, namely a block-folded geosynclinal province.

As such, this province was clearly defined as early as the upper Paleozoic. This was reflected in the formation of the corresponding tectonic forms, in the various trends of their development, and in the local deposition of some of the molasse formations (and perhaps of some others, yet unknown). The time of the initiation of the northern Tien Shan block-folded geosynclinal province is not known. It may be assumed with a fair degree of certainty that the process of its development was long and complex, and probably ran different courses in different parts of Tien Shan.--From auth. concl.

3-1792. Johnson, Ross B. PATTERNS AND ORIGIN OF RADIAL DIKE SWARMS ASSOCIATED WITH WEST SPANISH PEAK AND DIKE MOUNTAIN, SOUTH-CENTRAL COLORADO: Geol. Soc. America, Bull., v. 72, no. 4, p. 579-589, 4 figs., pl., Apr. 1961, 16 refs.

W. Spanish Peak and Dike Mountain in S.-central Colorado are stocks which cut Tertiary sedimentary rocks near the axis of the La Veta syncline, the structural trough of the Raton basin. Associated with these stocks are radial dike swarms. The outline of the W. Spanish Peak dike swarm is elliptical. The Dike Mountain swarm is more radial, and its outline is oval. Both systems are elongated normal to the axis of the La Veta syncline.

The dikes of the W. Spanish Peak swarm are of diverse rock types and represent several separate magmatic phases. Those of the Dike Mountain swarm are facies of syenodiorite and probably represent a single phase of magmatic invasion.

The dikes occupy vertical joints that have been generally attributed to radial fissuring during doming of the sedimentary rocks by the emplacement of the stocks. Structural studies, however, indicate that several systems of shear and tension joints resulted from intermittent orogenic stresses of varying direction and magnitude during folding of the syncline before invasion of the magmas, and the writer suggests that selective intrusion into this joint complex accounts for the dike patterns.--Auth.

3-1793. Platt, Rutherford. ARE THE EARTH'S CONTINENTS ADRIFT?: Reader's Digest, v. 78, no. 467, p. 181-182, 184, 186, 188, map, March, 1961.

The several lines of evidence offered to date in support of the theory of continental drift originally proposed by Alfred Wegener are summarized in a popular account. The evidence includes continental shapes, lithologic and structural similarities in widely separated mountain ranges, similar floras and faunas living in widely separated areas, fossil evidence such as Glossopteris, and remanent magnetism. The mechanism of drift is convection within the mantle.--M. Russell.

3-1794. Charlesworth, H. A. K. SOME OBSERVATIONS ON THE ORIGIN OF THE EARTH'S CRUST: Edmonton Geol. Soc., Quart., v. 4, no. 2, p. 1-7, diags., 1960, 14 refs.

An attempt is made to relate briefly and simply some current concepts concerning the nature and origin of the sial and sima. As the development of the crust is almost certainly related to processes taking place at depth, some mention is made of the mantle.

The surface of the earth was probably molten and consisted of basic magma. Later, a thin crust of basalt began to consolidate, which gradually thickened by extrusion of basic lava on the surface. Eventually basalt at the base of the crystalline layer began to be transformed into eclogite, at which point the boundary known as the Mohorovičić discontinuity came into existence. Further volcanic activity at the surface led to an increase in the thickness of the eclogite column.

Extrusion of andesitic lava led to the initiation of continental nuclei, around which the future continents grew by accretion. The final pattern of segments making up a continent is controlled by the history of relative movement of the continent with respect to the adjacent oceans and whether the continent has remained whole or partially disintegrated at some point in the past. Eventually continental sial will probably cover the entire earth's surface, at which point continental drift will no longer be possible and the present type of mountain building will come to an end.--From auth., p. 1, 6.

3-1795. Hill, Gladwin. SEA FLOOR DRILLED 2 MILES DOWN: New York Times, v. 110, no. 37,688, p. 1, col. 4-6, p. 15, col. 4-5, fig., map, Apr. 1, 1961.

American scientists, engineers and oil-field hands brought up a gray green Miocene clay core from 234 ft. below ocean bottom in a test of drilling in ocean water 2 mi. deep near Guadelupe Island about 260 mi. S. of Los Angeles, California. A prelude to Project Mohole, the test was hailed as opening a new era in oceanography and earth study.--M. Russell.

3-1796. Noble, Donald C. STABILIZATION OF CRUSTAL SUBSIDENCE IN GEOSYNCLINAL TERRANES BY PHASE TRANSITION AT M: Geol. Soc. America, Bull., v. 72, no. 2, p. 287-291, 3 figs., Feb. 1961, 8 refs.

Isostatic calculations indicate that a mechanism of geosynclinal subsidence based on a phase transformation at the M discontinuity possesses an inherent stability that will tend to maintain the upper surface of sediments near sea level regardless of fluctuations in the rate of geoisotherm depression or in the rate of sedimentation.

This effect may help in the understanding of sedimentation in geosynclinal and stable-shelf terrane.--Auth.

3-1797. Mathewson, Donald E. SOME NOTES ON PRECAMBRIAN STRUCTURES IN ARIZONA: Arizona Geol. Soc., Digest, v. 3, p. 9-11, 1960, 12 refs.

The general concept of NE.-SW. trend for most "lower group" Precambrian rocks may be in part unjustified. A significant N.-S. trend related to the Beltian trough is suggested.--M. Russell.

3-1798. Hoppin, Richard A. PRECAMBRIAN ROCKS AND THEIR RELATIONSHIP TO LARAMIDE STRUCTURE ALONG THE EAST FLANK OF THE BIGHORN MOUNTAINS NEAR BUFFALO, WYOMING: Geol. Soc. America, Bull., v. 72, no. 3, p. 351-367, 5 figs., 5 pls., March 1961, 30 refs.

Precambrian crystalline rocks and younger sedimentary rocks were involved in Laramide deformation in the western part of the United States. Near Buffalo, Wyoming, 2 high-angle dextral faults striking N. 10°E. cut both the upturned sedimentary rocks and the crystalline basement. As this trend does not correspond to directions of transcurrent faulting expected with ENE.-WSW. compression (indicated by the NNW.-trending Clear Creek thrust and upturned sedimentary rocks), the writer studied Precambrian rocks to see if basement structure controlled the strike of the N. 10°E. faults.

The Precambrian complex consists of quartz-biotite-plagioclase gneiss and migmatite with minor hornblende gneiss and amphibolite. These rocks are greatly deformed and partly granitized. Mafic dikes and small ultramafic bodies cut the complex. Early foliation and layering are obscured by later shear fracturing. Three prominent directions of high-angle fractures are N. 10°E., N. 45°E., and N. 75°-80°W.

In the sedimentary rocks, N. 45°E. and N. 75°E.-N. 75°W. fracture sets are well developed; the N. 10° E. set is poorly developed.

The pronounced development of the N. 10°E. fractures and shear zones in the Precambrian rocks and absence of these structure trends in the sedimentary rocks suggest that these fractures and shears were formed during a Precambrian deformation and provided zones of weakness which controlled Laramide tear faulting. Three diabase dikes in the Precambrian rocks between the faults also follow this direction.

The other 2 trends cutting both the gneisses and the sedimentary rocks are probably Laramide in age, although an E.-W. dike and a NE.-trending dike in the S. end of the area suggest that movement was reactivated along older Precambrian fractures.--Auth.

3-1799. Levenshteyn, M. L. STRUCTURE OF THE SOUTHWESTERN EDGE OF DONBAS (AN ANALYSIS OF THE CHANGE IN THICKNESS OF THE COAL MEASURES): Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 4, p. 73-79, 2 maps, table, pub. 1960, 17 refs.

Analysis of the data on the thickness of coal deposits in southwestern Donbas reveals the following patterns, common to all formations: 1) the isopachs trend northwesterly, corresponding to the outlines of the crystalline massif; and 2) the thickness of all formations increases to the NE. An analysis of the average thickness increase over 1 km. across the isopach trend shows that there seems to be a definite relationship between the rate of the thickness change, which reflects the differential vertical movement of the area, and the facies composition of the section. The higher the rate of change, the more intensive the facies changes.

The northeasterly thickening of Carboniferous sediments is accompanied by a change in tectonic forms, which suggests that quantitative changes here are combined with a radical change in the geotectonic conditions. The Ukrainian crystalline massif - including its Azov block - is regarded as an upper Paleozoic platform area.

The sedimentary complex of southwestern Donbas is located in the area of the northern slope of the platform and on the S. part of the Donets downwarp, with an environment transitional from the platform to geosynclinal.

A similarity with the southern edge of the Dnepr-Donets trough is readily seen in this structural picture of the southwestern rim of the Donbas. A genetic relationship between the 2 regions is suggested which is expressed in a common sedimentary basin and in the community of their main structural elements. The Krovorozhye-Pavlovsk fault zone is correlative with (or a continuation of) the peripheral faults bounding in the S. the central graben of the Dnepr-Donets trough.

It is recommended that the SW. rim of the Donets basin be explored for oil and gas prospects similar to the known fields of the Dnepr-Donets trough.--L. M. Dane.

3-1800. Gzovsky, M. V., and others. MAP OF THE YOUNGEST TECTONIC MOVEMENTS IN CENTRAL ASIA: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 8, p. 772-776, fold. map, pub. 1961, 50 refs.

The authors discuss a method for constructing a map of the tectonic movements in central Asia which shows the total vertical crustal displacement during Neogene and Quaternary.--Auth.

4. STRATIGRAPHY AND HISTORICAL GEOLOGY

See also: Areal and Regional Geology 3-1762, 3-1763; Structural Geology 3-1798, 3-1799; Paleontology 3-1834, 3-1835, 3-1837; Mineralogy 3-1950; Igneous and Metamorphic Petrology 3-1958, 3-1963, 3-1964; Sedimentary Petrology 3-1982, 3-1983, 3-1986, 3-1994, 3-1995, 3-1997; Fuels 3-2085.

3-1801. Hedberg, Hollis D. THE STRATIGRAPHIC PANORAMA (AN INQUIRY INTO THE BASES FOR AGE DETERMINATION AND AGE CLASSIFICATION OF THE EARTH'S ROCK STRATA): Geol. Soc. America, Bull., v. 72, no. 4, p. 499-517, Apr. 1961, 49 refs.

Stratigraphy means literally the descriptive science of strata. It deals with the composition, form, arrangement, distribution, succession, and classification of rock strata, and it also involves the interpretation of these features in terms of mode of origin, environment, age, history, relation to organic evolution, and relation to other geologic concepts. Stratigraphy concerns itself with the complete picture of the rocks of the earth's crust as strata of various kinds and the significance of these strata in the earth's geological development.

There are many branches of stratigraphy, depending on the particular features of rock strata under consideration. One of the most important is chronostratigraphy which deals with the age determination and age classification of strata. Its basic purpose is to interpret the history of the earth through the chronologic sequence of its rock strata.

The principal means used to work out chronostratigraphy are 1) the physical interrelations of strata, 2) the relation of strata to sequence of organic evolution, and 3) radioactivity age determinations. Valuable supplementary evidence of age or chronostratigraphic position can be supplied by other features of rock strata and other geologic phenomena such as lithology, mineralogy, ore deposits, chemical composition, paleomagnetism, paleoclimatology, changes in sea level, orogeny, igneous activity, and unconformities. However, few of these can be proved to have had effects which were distinctly recognizable, identical in character, and synchronous over the whole world. Coordinated utilization of all possible lines of relative and absolute age determination and time correlation offers the best promise for continued progress in chronostratigraphy.

Joined to the problem of the dating of strata and the establishment of their sequence with respect to earth history is the task of chronostratigraphic classification. The record of 4 thousand million years, written in millions of cubic miles of strata, is too vast to be comprehended as a whole, and it is necessary to break it down into smaller more practicable units. The only adequate reference standards for the scope of these chronostratigraphic units are specifically designated intervals of rock strata – stratotypes.

The fundamental unit of world-wide chronostratigraphic classification is the system. The systems, largely established in Western Europe during the first half of the last century, were originally thought to constitute "natural" units with respect to earth history. In view of the local and rather haphazard manner in which most of them originated and the primitive state of world geological knowledge at that time, it is difficult now to see them as "natural" divisions of world-wide extent. Nevertheless the belief is still supported by many, including the U.S.S.R. Stratigraphic Commission, that the systems are marked off by a concurrence of major events in geologic history and major changes in the course of organic evolution. They assume that all lines of stratigraphic evidence converge to form "natural" divisions of strata with respect to time and that hence separate kinds of stratigraphic classification – lithostratigraphic, biostratigraphic, etc. – are unnecessary.

On the other hand, investigations by other competent workers of the evidence for world-wide "natural breaks" in either the diastrophic record or the record of organic evolution have resulted in strong judgments to the contrary. The conclusion seems reasonable, regardless of what may be proved eventually, that it has not yet been demonstrated that world-wide "natural breaks" in the general character and continuity of strata exist at the scale of the presently accepted geologic systems nor that the evidence at the boundaries of the present systems is such as to allow them to be considered as the "natural" world-wide division points of the chronostratigraphic scale. Rather, the evidence suggests that our geologic systems are only arbitrary chronostratigraphic units in a continuum characterized by intricately overlapping and not necessarily coincident changes in the many and various properties and attributes of rock strata and that their principal significance is that of standard units of chronostratigraphic reference, independent of other kinds of stratigraphic classification. Regardless of opinion on the relation of these units to events of earth history, the critically important point is that the systems and their major subdivisions should be tied down by international agreement to specifically designated and delimited sequences of rock strata – stratotypes – so as to provide a uniform basis of definition for everyone.--Auth.

3-1802. Ross, Reuben James, Jr. DISTRIBUTION OF ORDOVICIAN GRAPTOLITES IN EUGEOSYNCLINAL FACIES IN WESTERN NORTH AMERICA AND ITS PALEOGEOGRAPHIC IMPLICATIONS: Am. Assoc. Petroleum Geologists, Bull., v. 45, no. 3, p. 330-341, fig., March 1961, 102 refs.

Graptolite-rich detrital Ordovician rocks of siliceous, argillaceous, and volcanic composition are exposed in scattered areas in westernmost North America from Convict Lake in the Sierra Nevada, through Nevada, central Idaho, British Columbia, and Yukon Territory to Alaska. The paleogeographic relation of this facies to that of carbonate rocks, rich in shelly faunas, is not everywhere clear. In Alaska large areas of Ordovician eugeosynclinal rocks may lie unrecognized.

Though graptolites are disappointing as paleoecologic indices in the eugeosyclinal strata, their presumed planktonic or epiplanktonic habit should be useful in reconstruction of former ocean currents and the lands between which they flowed.--Auth.

3-1803. Belichenko, V.G., and others. STRATIGRAPHY AND METAMORPHISM OF ANCIENT ROCKS IN THE CENTRAL PART OF THE BARGUZINSK RANGE: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 4, p. 30-40, 7 figs., table, pub. 1960, 11 refs.

The controversial Barguzin and Nyandoni formations of the Barguzin range are assigned to the upper Proterozoic because 1) they are overlain unconformably by deposits with Lower Cambrian fauna, and 2) the section is identical to the upper Proterozoic of the central Ikatsk range and similar to the ternary Baikal complex. Stratigraphic unity of the Barguzin and Nyandoni formations is proven by common metamorphism by the Barguzin granitoids. Regional and contact metamorphism is described, with rock types related to source regions.--A. Eustus.

3-1804. Kalyuzhny, V. A. THE ANCIENT METAMORPHIC ROCKS AND THE METALLOGENY OF THE TIMAN REGION: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 6, p. 55-74, 7 figs. incl. map, 3 tables, pub. 1961, 17 refs.

Metamorphic rocks of the Russian platform outcrop in the Timan region and form a chain of separate blocks stretching from Dzhezhim-Parma in the SE. to the Cheshskaya Guba (bay) in the NW. Deep drillings showed that the metamorphic rocks were unconformably and transgressively covered by Paleozoic sedimentaries. The author compiles the results of prospecting drilling operations and gives a detailed description of metamorphics in 5 different parts of the Timan region. Comparison of the cross-sections of these 5 parts and the study of outcropping blocks, showed that all the metamorphic strata forming the basement complex of the Russian platform could be divided into 4 suites, all presumably upper Proterozoic or Cambrian. All 4 suites are better preserved in those parts of the region which were not involved in mountain building. Intrusive rocks were also found in different parts of the Timan region, represented by granitoid rocks, quartz syenites, monzonites, and diabase. There were 2 sedimentary cycles and 2 folding phases, accompanied by intrusion of magmatic rocks. The lower Chetlasskaya suite was formed during the first cycle before being involved in an orogenic process during which the intrusion of gabbro and nepheline syenites occurred. The other 3 suites were formed during the second sedimentary cycle and form a single transgressive complex. The second folding phase occurred at the end of the Bystrukhinsky period and is associated with the intrusion of granite and syenite magma. The author concludes that the occurrence of erosion surfaces on the schistose beds indicates a possible reworking and concentration of zircon-Ti ores, as well as other rare minerals.--From LC.

3-1805. Hutchison, Charles S. THE BASEMENT ROCKS OF MALAYA AND THEIR PALEOGEOGRAPHIC SIGNIFICANCE IN SOUTH-EAST ASIA: Am. Jour. Sci., v. 259, no. 3, p. 181-185, 2 figs., March 1961, 9 refs.

In northeastern Malaya a N.-S.-trending belt of schists of amphibolite facies of apparently anticlinal form is overlain unconformably to the E. and W. by Carboniferous sediments. It is suggested that these schists are of Precambrian age and represent a remnant of a N.-S. axis which was active during the Paleozoic. The control of this axis on the paleogeography of Malaya appears to have been very great up to the end of the Devonian.--Auth.

3-1806. Pierce, G. R., and others. FOSSILIFEROUS PALEOZOIC LOCALITIES IN MÉRIDA ANDES, VENEZUELA: Am. Assoc. Petroleum Geologists, Bull., v. 45, no. 3, p. 342-375, 17 figs., March 1961, 31 refs.

Despite both the paucity of information relative to Paleozoic sedimentation and the lack of systematic publication of data by various workers, the deposition of marine fossiliferous strata during this era was widespread in western Venezuela. This current study of the fossiliferous Paleozoic sedimentary strata of the Mérida Andes of western Venezuela and the availability of supporting data from Colombia and Ecuador attest the extensive deposition of marine fossiliferous rocks during the Cambrian, Ordovician, Devonian, Pennsylvanian, and Permian periods. In Venezuela the extent of Paleozoic sediments into areas which have not been subjected to subsequent metamorphism is no doubt much greater than heretofore supposed. The probabilities of thin to thick remnants of Paleozoic sediments capping the Guayana shield extending beneath the llanos of western Venezuela and the possibilities within these remnants for source and (or) reservoir beds of petroleum are not beyond conjecture.

Thirteen marine fossiliferous Paleozoic localities from the Mérida Andes of western Venezuela are described in detail. In addition to the systematic presentation of stratigraphic data for each area, the illustrations include location maps giving distribution of the Paleozoic strata and their accessibility.

Marine deposition was widespread in western Venezuela during the Paleozoic. The most extensive marine record is that of the late Paleozoic subera, the Mucuchachí group of the Devonian period. Silurian marine sediments are not known in Venezuela. Marine sediments of Pennsylvanian and Permian age are also widespread. All marine fossiliferous Paleozoic strata are in the southeastern sector of the Mérida Andes.--Auth.

3-1807. Semikhatov, M.A. STRATIGRAPHY AND GEOLOGIC HISTORY OF THE EARLY CAMBRIAN IN THE NORTHERN PART OF THE YENISEY RANGE: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 7, p. 63-76, 4 figs. incl. 2 maps, pub. 1961, 13 refs.

Lower Cambrian rocks of the region are divided into 5 suites: Lopatinsk, Chivida, Vorogovka, Nemchana and Lebyazhya. The first 4 conditionally belong to the Aldan stage and the last to the Lena stage of the Lower Cambrian. The Lopatinsk suite is composed of red-brown conglomerates, 3 m. thick overlain by 400-450 m. of red, fine-grained sandstone. The Chivida suite is composed of variegated terrigenous rocks and dolomite. The Vorogovka suite, coincident in time with the Chivida, is composed of dolomites, limestones, aleurolites, and sandstones. The Nemchana suite is composed of red medium-grained sandstones, dolomites, argillites, and aleurolites. The Lebyazhya suite is composed of dolomites interbedded with massive limestone. All these suites are conformable and represent a single sedimentation cycle; all 4 are equally dislocated and metamorphosed. In this, they are different from the underlying Proterozoic suites they cover with an angular unconformity. At the beginning of the Cambrian, 2 depressions were formed in the northern part of the Yenisey mountain range. The Lopatinsk and Chivida suites were accumulated in the eastern Teya depression and the Vorogovka suite in the western depression adjacent to the Yenisey river. The development of these structures continued into Nemchany time. The Teya depression became 4 km. deep but was completely filled up by the Nemchana suite.--From LC.

3-1808. Dawson, T.A. DEEP TEST WELL IN LAWRENCE COUNTY, INDIANA: DRILLING TECHNIQUES AND STRATIGRAPHIC INTERPRETATIONS: Indiana, Geol. Survey, Rept. Prog. no. 22, 36 p., 7 figs., pl., 5 tables, 1960.

The Indiana Farm Bureau Cooperative Association, Inc., No. 1 Luther Brown well in Lawrence County established a new depth record for Indiana of 6,806 ft. The well was drilled proficiently. Although the drilling cost of $92,541 is high as compared to the cost of the typical test well drilled in the Illinois basin, drilling probably was effected at a near minimum cost figure. The well is far removed from other deep test wells. As a consequence, important new data on the lithologic character and thickness of the Knox dolomite, Eau Claire formation, and Mt. Simon sandstone were obtained from it. This lower Ordovician and Cambrian rock section is 4,290 ft. thick in the well.--From auth.

3-1809. Sanders, John E., and others. BALD MOUNTAIN LIMESTONE, NEW YORK: NEW FACTS AND INTERPRETATIONS RELATIVE TO TACONIC GEOLOGY: Geol. Soc. America, Bull., v. 72, no. 3, p. 485-487, March 1961, 12 refs.

The "Bald Mountain limestone" of Ruedemann has been found to consist of the upper part of the autochthonous carbonate-rock sequence of the Champlain-Hudson valleys and not to be part of the Taconic sequence. At Bald Mountain this carbonate-rock sequence is overlain unconformably by the Snake Hill shale, with local basal limestone-pebble conglomerate (Rysedorph Hill conglomerate of Ruedemann). The Taconic thrust is present; along it the fossiliferous Lower Cambrian and younger fine-grained terrigenous rocks of the allochthonous sequence have been thrust over the autochthonous Middle Ordovician graptolite-bearing black shale.--Auth.

3-1810. Weiss, Malcolm P. THE AMERICAN UPPER ORDOVICIAN STANDARD. V. A CRITICAL APPRAISAL OF THE CLASSIFICATION OF THE TYPICAL CINCINNATIAN BEDS: Geol. Soc. America, Bull., v. 72, no. 4, p. 645-647, Apr. 1961, 18 refs.

The large number of classifications of the type Cincinnatian (Ordovician) are to a great extent variations of a few fundamental concepts. Each of these elements is a least 40 years old and founded in the more rigid stratigraphic faiths of those times.

Progress in the understanding of the Cincinnatian requires a new look from the standpoint of modern stratigraphic principles; further rearrangement of older concepts and named units is fruitless.--Auth.

3-1811. Zhizhina, M.S. AGE OF PALEOZOIC DEPOSITS ON THE KOTELNYY ISLAND: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 4, p. 90-91, pub. 1960, 4 refs.

A total of 18 Silurian and Devonian coral forms were identified from Kotelnyy island in the Soviet Arctic. The presence of hitherto unrecognized Upper Ordovician rocks is established, and Silurian deposits are divided into Llandoverian-Wenlockian, Wenlockian-Ludlowian, and Ludlowian.--M. Russell.

3-1812. Markova, N.G. SILURIAN DEPOSITS OF THE KARGABULAK SPRINGS AREA: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 7, p. 77-83, map, secs., pub. 1961, 2 refs.

These deposits in western lake Balkhash region form the edge of a synclinal structure which is the northwestern extremity of the so-called Arkhaz-Sarytuma coal-bearing trough. They can be divided into 3 suites. The lowest is formed of porphyrites of andesitic and basaltic composition with some tuffs and agglomerates in the lower part and sandstones in the upper part. It is about 300 m. thick. The next suite, 150-180 m. thick, is formed of tuffaceous sandstone with seams of ash tuff. The upper suite, about 350 m. thick, is formed of red conglomerates, arkose sandstones and a thick layer of limestone. This third suite belongs to the Wenlock and Ludlow stages. Comparing the cross sections of the Kargabulak and the Mynaral regions, 75 km. apart, the author admits the possibility that the first and the second suites of the Kargabulak region are analogous respectively to the Llandoverian and Tarannonian of the Mynaral region. The upper parts of both cross-sections are identical.--From LC.

3-1813. Reavely, George H., and C.G. Winder. THE SYLVANIA SANDSTONE IN SOUTHWESTERN ONTARIO: Can. Mining & Metall. Bull., v. 54, no. 586, p. 139-142, 8 figs., table, Feb. 1961, 14 refs.

The lower Middle Devonian Sylvania sandstone occurs in the subsurface in the western part of Malden township, Essex county. The formation is composed of well-rounded, frosted quartz grains with a silica content varying from 42 to 93%, and the grains are cemented by carbonate, constituting up to 57% of the rock. This sandstone is not a homogeneous bed but is divided by strata rich in carbonate cement. The thickness of the Sylvania in Malden township varies up to a known maximum thickness of 88 ft. The lower contact with the chert-bearing Bois Blanc formation is sharp, but the upper contact with the Amherstburg formation (Detroit River group) exists as a transition by a gradual downward increase in quartz grains. The Sylvania would seem to outcrop in the lake bottom near the mouth of the Detroit River dipping to the N. along a broad anticline, the axis of which follows the Detroit River. Just S. of Amherstburg, a local E.-W.-trending flexure brings the Sylvania to the bedrock surface. Outcropping in the bottom of the Amherstburg channel has been confirmed by dredging at the S. end of Bois Blanc Island. --Auth.

3-1814. Fagerstrom, John A. AGE AND STRATIGRAPHIC RELATIONS OF THE FORMOSA REEF LIMESTONE (MIDDLE DEVONIAN) OF SOUTHWESTERN ONTARIO, CANADA: Geol. Soc. America, Bull., v. 72, no. 3, p. 341-349, map, 2 tables, March 1961, 24 refs.

The Formosa reef limestone consists of a localized 3-dimensional cluster of very pure, massive limestone reefs (bioherms) outcropping as irregular knobs in a roughly elliptical area in southern Bruce and northern Huron counties, Ontario. Outcrop and subsurface evidence indicates that the reefs are small, numerous, scattered over an outcrop area of about 150 sq. mi. and occur through a stratigraphic interval of approximately 200 ft. within the brown, bituminously laminated dolomite of the Detroit River group (undifferentiated), which is about 240 ft. thick in the area.--Auth.

3-1815. Skipp, Betty A. L. INTERPRETATION OF SEDIMENTARY FEATURES IN BRAZER LIMESTONE (MISSISSIPPIAN) NEAR MACKAY, CUSTER COUNTY, IDAHO: Am. Assoc. Petroleum Geologists, Bull., v. 45, no.3, p. 376-389, 4 figs., 2 tables, March 1961, 15 refs.

The Brazer limestone (Mississippian) 12 mi. W. of Mackay in Custer County, Idaho, has sedimentary features that aid in interpreting the Mississippian history of the region. The rocks, approximately 7,400 ft. thick, range in age from Osage to late Meramec, possibly Chester, as determined from endothyrid Foraminifera. They are underlain by about 4,000 ft. of siliceous argillites (probably Lower Mississippian) and overlain by Challis volcanics (Tertiary).

In this area, the Brazer consists of limestones with intercalated quartzose clastic rocks. The limestones change from fine-grained, impure, nonfossiliferous or foraminiferal in the lower part of the section to calcarenitic, pure, and very fossiliferous in the upper part. This change is accompanied by a corresponding increase in coarseness of the associated quartzose clastic rocks from fine siltstones to pebble conglomerates.

The conglomerate beds, all lenticular and quartzose, are restricted to the upper 3,000 ft. of the section. They can be divided into those that have characteristics of beaches and those that resemble turbidity current deposits.

Petrographic studies, faunal assemblages, and the great thickness of the Brazer in this area suggest that it was deposited in a marginal miogeosynclinal environment. The lower part was laid down in shallow, quiet marine waters, the middle in freely circulating marine waters of moderate depth, and the upper in a fluctuating marine environment near a low landmass probably on the W. or SW. Orogenic movements involving the landmass in Late Mississippian time are recorded in the conglomerates.--Auth.

3-1816. Lees, Alan. THE WAULSORTIAN "REEFS" OF EIRE: A CARBONATE MUDBANK COMPLEX OF LOWER CARBONIFEROUS AGE: Jour. Geology, v. 69, no. 1, p. 101-109, 5 figs., Jan. 1961, 27 refs.

The main features of the Waulsortian (upper

Tournaisian and lower Visean) carbonate mudbank complex of Eire are described and the paleogeography outlined. The distribution and lithological characters of the Waulsortian limestones and associated sediments are briefly described.

The Waulsortian rocks comprise a large mudbank complex, together with numerous discontinuous banks which formed in the lagoon on the landward side of the complex. The complex originally extended over an area of about 7,000 sq. mi. in Eire. Thickness variations are shown on an isopach map. The development of the complex was controlled by 2 (or more) stable structural blocks on the Variscan foreland. These allowed the accumulation of a great thickness of Waulsortian limestone in the Shannon (NW. Co. Limerick and S. Co. Clare) and Cork areas before lateral spreading began.

Bank growth took 2 main forms. These, the knoll and sheet forms, are briefly described and illustrated. The mechanism of growth is less certain. It is suggested that the banks are accretionary structures formed in situ by accumulation of carbonate mud and bioclastic sand trapped and retained by organisms, probably plants, which are not preserved. Bryozoa acted as auxiliary supporting structures in some cases but do not form a framework.--Auth.

3-1817. Feofilova, A.P. FACIES ENVIRONMENT OF LOWER CARBONIFEROUS COAL-MEASURES ACCUMULATION [IN] THE DONETS BASIN: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 5, p. 28-39, 6 figs., 4 tables, pub. 1960, 6 refs.

Facies environments of the lower Carboniferous coal measures accumulation in the Donbas are identified and described on the basis of detailed lithological observations. The author concludes that the entire industrial coal-bearing capacity is related to a stable development of a lagoonal environment. Graphs are presented to illustrate the marsh facies content as a function of the development of a lagoonal environment, and the coal-content coefficient as a function of the marsh facies content. The author deems these data useful as a means of prediction.--Auth.

3-1818. Kucherenko, M.T., and A.V. Sokolskaya. LITHOLOGIC-FACIES DESCRIPTION OF THE LOWER CARBONIFEROUS CARBONATE SERIES ON THE NORTHERN SLOPE OF THE UKRAINIAN CRYSTALLINE MASSIF: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 5, p. 40-47, pub. 1960, 18 refs.

Tournaisian and lower Visean deposits in the northern slope of the Ukrainian crystalline massif are described. It is established that the carbonate sequence wedges out gradually, going westward, instead of being fully replaced by terrigenous sediments. For this reason, terrigenous and carbonate deposits of the western Donbas districts, formerly correlated with the Donbas C_1^Vf zone, are really correlative with the C_1^Vg zone.--Auth.

3-1819. Friedman, S.A. CHANNEL-FILL SANDSTONES IN THE MIDDLE PENNSYLVANIAN ROCKS OF INDIANA: Indiana, Geol. Survey, Rep. Prog. no. 23, 59 p., 16 figs., 2 pls., table, 1960.

Data from coal-test boreholes and outcrops show that channel-fill sandstones occur at 32 localities in western Indiana in the Brazil, Staunton, Linton, Petersburg, and Dugger formations of middle Pennsylvanian age. These sandstones average 40 ft. thick, 3 mi. long, and a quarter of a mile wide at the top and commonly trend southwestward down the regional dip. At least 9 different coal beds are cut out or replaced locally by these channel-fill sandstones.

Four classes of channel-fill sandstones are recognized in Indiana. Channel-fill sandstones of class 1 form a dendritic pattern and trend and thicken downdip. Those of class 2 also form a dendritic pattern and trend downdip without thickening. Channel sandstones of class 3 do not form a dendritic pattern but also trend downdip. Those of class 4 do not trend downdip; instead, they are parallel to the regional strike, and they do not have a dendritic pattern.

The channel-fill sandstones are light brown or red brown, thick bedded and crossbedded, medium-grained to coarse-grained, and micaceous. Their bases rest disconformably on underlying strata, and they represent the lowest stratigraphic unit in a cyclothem. Paleotopography, influenced by differential compaction of sandstone and shale, underlying structure, and a southwesterly regional slope determined the geographic distribution and orientation of the channel-fill sandstones.

The periodic lowering of sea level during middle Pennsylvanian time probably exposed the Cincinnati arch and thus permitted consequent subaerial streams to erode the channels and fill them mostly with sand on at least 6 different occasions. Possibly most of the channel-fill sandstones were derived from the Pottsville (lower and middle ? Pennsylvanian) and the Chester rocks that were presumably on the arch.

The Coxville sandstone, first referred to by G. H. Ashley in 1899, is herein proposed as a member at or near the base of the Linton formation of the Allegheny series (middle Pennsylvanian) in Indiana. The Palzo sandstone of Illinois probably is correlative with the Coxville sandstone member.--Auth.

3-1820. Wayne, William J. STRATIGRAPHY OF THE OHIO RIVER FORMATION: Indiana, Geol. Survey, Bull. 21, 44 p., 3 figs., 3 pls., 2 tables, 1960.

The Ohio formation is a body of poorly consolidated medium- to fine-grained quartz sand in southern Indiana and northern Kentucky. It overlies limestones of middle Mississippian age in a narrow belt from near Salem, Indiana, to S. of Fort Knox, Kentucky. Although regarded as a "ridge top" sand, the Ohio River formation does not cap the highest hills; the formation was beveled along with the surrounding rocks during the later Tertiary cycle of erosion. Remnants of the formation range from a few inches to more than 80 ft. in thickness.

This sand body is better sorted than the sandstone in either of the 2 Paleozoic formations with which it has been compared, the Big Clifty formation of the Chester series or the Mansfield formation of the Pottsville series. Physical characteristics of the formation are more similar to beach and dune sands than to sand deposits of other environments. The formation is not known to contain any fossils; thus its correlation must depend on physical criteria and paleogeographic interpretations. The only post-Paleozoic regional submergence during which the Mississippi embayment could have extended far enough inland to have provided deposition in this area took place during the Paleocene, when the Porter's Creek clay was laid down in western Kentucky.

The major source of the sand probably was sandstones of the Chester and Pottsville series, which undoubtedly were present this far E. during the early part of the Tertiary. A thick, cherty, conglomeratic clay that separates the sand from the underlying limestone probably is residuum that mantled a late Cretaceous erosion surface.--Auth.

3-1821. Richard, Kenyon E., and James H. Courtright. **SOME CRETACEOUS-TERTIARY RELATIONSHIPS IN SOUTHEASTERN ARIZONA AND NEW MEXICO: Arizona Geol. Soc., Digest, v. 3, p. 1-7, map, chart, 1960, 11 refs.**

Volcanics and clastics of the Silver Bell-Claflin Ranch types have been observed in several localities where they have been mapped as Cretaceous-Tertiary extrusives unconformably overlying Cretaceous.

The interval between the Tucson surface and the overlying acid pyroclastics of the Cat Mountain rhyolite type is described as being occupied principally by 2 formations: the older clastics of the "Claflin Ranch" or chaos type and the younger andesites of the "Silver Bell" type. There may have been repeated episodes of deposition of clastics and volcanics, with local intervals of erosion. Thus, the sequence may be found to differ in order and number of units from place to place. These rocks as a group are lithologically similar over wide areas. They lie on an erosion surface cut in Cretaceous and older rocks, and this surface usually marks a pronounced change in the environment of sedimentation.--From auth., p. 4.

3-1822. Lance, John F. **STRATIGRAPHIC AND STRUCTURAL POSITION OF CENOZOIC FOSSIL LOCALITIES IN ARIZONA: Arizona Geol. Soc., Digest, v. 3, p. 155-159, fig., 1960, 11 refs.**

The discovery of several new fossil localities in Arizona during the last 10 years warrants the development of an outline of Cenozoic history which may be useful as a guide for further work. In southern Arizona almost continuous orogeny lasted from late Cretaceous to Miocene. The central mountainous area was uplifted from early Miocene to early Pliocene. Volcanic activity was intermittent. The major drainageways were developed after the Laramide uplift. Disruption of southwesterly drainage from the Plateau region, cutting of gorges, and formation of basin-and-range topography were largely Miocene events. Pliocene structural movement, volcanic activity, and diversion of waters resulted in complex changes of the drainage pattern. Sedimentation in some valleys of E.-central and southeastern Arizona continued until mid-Pleistocene. Alluvial fans and pediment gravels covered fine-grained Pliocene and lower Pleistocene beds during middle and late Plesitocene.--M. Russell.

3-1823. Heindl, L.A. **CENOZOIC GEOLOGY OF THE PAPAGO INDIAN RESERVATION, PIMA, MARICOPA, AND PINAL COUNTIES, ARIZONA (A PRELIMINARY SUMMARY): Arizona Geol. Soc., Digest, v. 3, p. 31-34, 1960, 3 refs.**

The Papago Indian Reservation includes about 4,300 sq. mi. in central Pima County. Cenozic rocks comprise a diverse series of sedimentary, intrusive, and volcanic sequences. They generally rest with angular unconformity on Precambrian, Paleozoic, or Mesozoic intrusive or sedimentary rocks. Locally, the oldest Cenozoic rocks may represent a continuation of late Mesozoic deposition. Elsewhere, the younger Cenozoic rocks lie on intrusive or metamorphic rocks of possible late Mesozoic or early Cenozoic age. In many areas, the base of the Cenozoic rocks is not exposed.

The Cenozoic and associated rocks are divided into 4 arbitrary age groups - Quaternary and Tertiary, late(?) Tertiary, middle(?) Tertiary, and Cretaceous and Tertiary. These are further subdivided into 14 sedimentary or volcanic sequences and 3 episodes of intrusion. Although only 3 intrusive episodes are described, small intrusive bodies are associated with all periods of extrusion.--From auth., p. 31.

3-1824. Vasilev, Yu. M. **QUATERNARY DEPOSITS IN THE NORTHERN CASPIAN REGION: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 5, p. 48-59, 2 figs., pub. 1960, 23 refs.**

In describing the northern Caspian region Quaternary, the author refines the present concept of its stratigraphy. He differentiates the Khvalynsk stage into 3 formations instead of 2. The Singil and Astrakhan beds, assigned to the lower Khozarian formation by P.V. Fedorov, are taken out of it. New data are cited on very recent tectonic movements in the area.--Auth.

3-1825. Seff, Philip. **PRELIMINARY REPORT OF THE STRATIGRAPHY OF THE 111 RANCH BEDS, GRAHAM COUNTY, ARIZONA: Arizona Geol. Soc., Digest, v. 3, p. 137-140, pl., 1960, 4 refs.**

A 152-ft. stratigraphic sequence of Pleistocene foodplain, paludal, and lacustrine deposits is exposed in the badlands topography of the 111 Ranch area SE. of Safford. Individual constituent lithologies in the sequence include sand, gravel, clay, marl, limestone, silt, tuffaceous silt, diatomite, and chert. --M. Russell.

3-1826. Scott, Glenn R. **SUBDIVISION OF THE QUATERNARY ALLUVIUM EAST OF THE FRONT RANGE NEAR DENVER, COLORADO: Geol. Soc. America, Bull., v. 71, no. 10, p. 1541-1543, map, table, Oct. 1960, 7 refs.**

Quaternary alluvial deposits near Denver include 5 hitherto unrecognized formations. Recognition and differentiation of the formations are based primarily on superposition, physiographic position, and ancient soils. Radiocarbon dates, fossils, and synchronous beds such as volcanic ash were used wherever available. The formations are here named: 1) Rocky Flats alluvium (Nebraskan or Aftonian), 2) Verdos alluvium (Kansan or Yarmouth), 3) Slocum alluvium (Illinoian or Yarmouth), 4) Louviers alluvium (early Wisconsin), and 5) Broadway alluvium (late Wisconsin). The writer believes that the recognition and application of these units is beginning to result in a better understanding of the geomorphic development of the High Plains E. of the Front Range. --B.W. Pipkin.

3-1827. Semenenko, N.P. **PRECAMBRIAN GEOCHRONOLOGY ON THE ABSOLUTE-TIME SCALE: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 5, p. 1-11, 3 tables, pub. 1960, 32 refs.**

All known Precambrian formations of the U.S.S.R.

are divided into groups according to their ages: the Precambrian of the Ukrainian shield form 7 age groups from 900 million to 2,600 million years old; the Baltic shield is composed of 7 age groups from 1,010 million to 3,480 million years; the Russian platform and Urals are composed of 5 age groups from 680 million to 1,740 million years old. The age of older formations underlying the Kursk Fe series is not yet determined. Siberia has 4 age groups from 500 to 1,900 million years old. Regional composition of each age group is given in detail. The age of similar formations of Canada and Africa are also given. Comparison of available data on the age of all known Precambrian rocks shows that there are 10 cycles of mineralization linked with 10 epochs of folding.

The following 5 great planetary megacycles represent the history of the earth (in millions of years): 1) fifth post-Cambrian megacycle with 3 folding epochs - from 500 to 600; 2) fourth Precambrian megacycle with 2 folding epochs - from 500 to 1,150; 3) third Precambrian megacycle with 3 folding epochs - from 1,200 to 1,850; 4) second Precambrian megacycle with 3 folding epochs - from 1,900 to 2,650; 5) first Precambrian megacycle with 2(?) folding epochs - from 2,650 to 3,500. The duration of folding epochs and mineralization cycles is about 150 million to 400 million years. The whole Precambrian system contains huge quantities of metallic deposits. Among other minerals 75% of the Au and 60% of the Fe and Mn mined are extracted from these rocks.--From LC.

3-1828. Rouse, Glenn E., and W.H. Mathews. RADIOACTIVE DATING OF TERTIARY PLANT-BEARING DEPOSITS: Science, v. 133, no. 3458, p. 1079-1080, table, Apr. 7, 1961, 17 refs.

Four K-Ar determinations from Tertiary rocks in the interior of British Columbia have yielded dates ranging from 45 to 49 million years. This suggests contemporaneity of 3 separate localities within the middle Eocene epoch. Abundant plant micro- and macrofossils support this conclusion and indicate a flora quite different from floras of comparable age in western United States.--Auth.

3-1829. Giletti, Bruno J., and Paul E. Damon. RUBIDIUM-STRONTIUM AGES OF SOME BASEMENT ROCKS FROM ARIZONA AND NORTHWESTERN MEXICO: Geol. Soc. America, Bull., v. 72, no. 4, p. 639-643, map, table, Apr. 1961, 12 refs.

Precambrian ages in the range 1,200-1,500 m.y. have been found by the Rb-Sr method for basement rocks in Arizona. The data extend the "1,350 m.y." orogeny to northwestern Arizona (Chloride granite) and southern Arizona (Oracle granite) near Tucson. Cretaceous-Tertiary ages were obtained from basement rocks in southern Arizona and northern Sonora, Mexico.--Auth.

3-1830. Rosholt, John N., Jr., and others. ABSOLUTE DATING OF DEEP-SEA CORES BY THE Pa^{231}/Th^{230} METHOD: Jour. Geology, v. 69, no. 2, p. 162-185, 8 figs., 10 tables, March 1961, 78 refs.

O isotopic analysis of *Globigerina*-ooze cores from the Atlantic and adjacent seas showed that surface ocean temperatures underwent numerous, apparently periodical, variations during the past few hundred thousand years. C^{14} dating showed that the last temperature minimum of the deep-sea cores was synchronous with the last major glaciation, the main Würm.

Previous attempts to date deep-sea cores were based on the decay of U-unsupported Th^{230}(ionium). This method requires, among other conditions, that the supply of U-supported Th^{230} in sea water and the rate of noncarbonate sedimentation remained essentially constant over the time interval to be dated. Attempts to correct for possible variations in the noncarbonate sedimentation rate have been made by using such ratios as Th^{230}/Th^{232} or Th^{230}/Fe_2O_3. The validity of these corrections is questionable because Th^{230} produced in sea water by the decay of U^{238} and U^{234} has a geochemical history different from that of Th^{232} and Fe_2O_3. The requirements mentioned above need not be met if the ratio Pa^{231}/Th^{230} is used. Since Pa^{231} and Th^{230} are daughters of the same element, U, and since they decay at different rates, their ratio is a function of time alone.

While information from deep-sea cores, bearing directly on Pleistocene history, has been obtained almost exclusively by isotopic and micropaleontological analysis of the foraminiferal component of *Globigerina*-ooze cores, dating by the decay of U-unsupported Th^{230} or by the ratio Pa^{231}/Th^{230} is based on the clay component where these nuclides are concentrated. Therefore, dating, by these 2 methods, of the stratigraphic record given by the foraminiferal component requires synchronism between the 2 components. Such synchronism may be exceptional, for the clay component may frequently or even generally contain some or much reworked material, even when the foraminiferal record is undisturbed. In such cases, the ages obtained may be generally greater than the ages of the events to be dated.

Pa^{231}/Th^{230} dating of 2 deep-sea cores from the Caribbean about 600 km. apart, has given a set of dates which are internally consistent; identical, within the limits of error, in stratigraphically equivalent levels of the 2 cores; and coincident with the C^{14} chronology. This set of dates is believed to provide a reliable, absolute time scale, extending from the present to about 175,000 years ago. Pa^{231}/Th^{230} and C^{14} measurements on deep-sea cores, C^{14}, measurements on continental material, paleotemperature analysis of deep-sea cores, and correlation of the temperature record of the deep-sea cores with continental events provide the following ages for Pleistocene stages: postglacial, 0-10,000 years; late and main Würm, 10,000-30,000 years; main Würm-early Würm interval, 30,000-50,000 years; early Würm, 50,000-65,000 years; Riss/Würm interglacial, 65,000-100,000 years; Riss, 100,000-130,000 years; and Mindel/Riss interglacial, 130,000-175,000 years. These ages are very close to or identical with the ages given by Emiliani. Correlation between temperature variations of the deep-sea cores and continental stages preceding the last interglacial, however, is only tentative. The apparent identity of the C^{14} and Pa^{231}/Th^{230} chronologies over the entire range of the C^{14} method indicates that the cosmic-ray flux did not change by more than a factor of 2 during the past 60,000 years.

Pa^{231}/Th^{230} dating of a deep-sea core from the North Atlantic gave ages which are consistently about 30,000 years greater than the Pa^{231}/Th^{230} ages obtained from the 2 Caribbean cores and the C^{14} chronology. This is believed to result from contamination by reworked clay, an effect which may actually exist in most deep-sea cores.

Rates of sedimentation of the carbonate fraction larger than 62μ, the carbonate fraction smaller than 62μ, and the noncarbonate fraction, calculated for the intervals between selected dated levels, appear not to have changed markedly when averaged over time intervals of some tens of thousands of years. The rates of sedimentation during the last 11,000 years, however, were lower than during previous time intervals.

A generalized temperature curve, calibrated in terms of the C^{14}-Pa^{231}/Th^{230} chronology, is presented. This curve is very close to the curve previously constructed by Emiliani.--Auth.

5. PALEONTOLOGY

See also: Geomorphology 3-1768; Stratigraphy 3-1802, 3-1811, 3-1828; Geochemistry 3-1904; Sedimentary Petrology 3-1997.

3-1831. Miller, Halsey W., Jr. THE PALEONTOLOGICAL LITERATURE OF ARIZONA: A REVIEW: Arizona Geol. Soc., Digest, v. 3, p. 63-70, 1960, approx. 120 refs.

Approximately 80 papers have been published that deal mainly with the invertebrate paleontology of Arizona. In addition to these, more than 40 stratigraphic papers containing either important lists, new occurrences, or stratigraphic or geographic ranges of invertebrate fossils have also been published. Most of the paleontologic work has been done in northern Arizona, especially in the Grand Canyon area.--From auth., p. 63.

3-1832. Osmundsen, John A. SCIENTISTS GROW 'BUGS' FROM SPACE: New York Times, v. 110, no. 37,693, p. 31, col. 1, p. 59, col. 2-3, Apr. 6, 1961.

Apparently living material capable of being grown in the laboratory has been recovered from a meteorite which fell at Murray, Kentucky, in 1950. Scientists at the National Institutes of Health, Bethesda, Maryland, have cultivated particles in the shape of twisted rods between 8 and 16 millionths of an inch long, derived from a crushed sample of the meteorite the surfaces of which had first been sterilized.--M. Russell.

3-1833. Jerison, Harry J. QUANTITATIVE ANALYSIS OF EVOLUTION OF THE BRAIN IN MAMMALS: Science, v. 133, no. 3457, p. 1012-1014, graph, March 31, 1961, approx. 10 refs.

Empirical equations derived from brain size (E) and body size (P) of archaic-Eocene, Oligocene, and Recent mammals were all of the form, $E = kP^{2/3}$; $k = 0.03$ for the Eocene, 0.06 for the Oligocene, and 0.12 for the Recent groups. It is suggested that k, which has been used as an index of cephalization in contemporary mammals, may be an appropriate measure of brain evolution in the mammals as a class.--Auth.

3-1834. Berry, William B. N. GRAPTOLITE FAUNA OF THE POULTNEY SLATE: Am. Jour. Sci., v. 259, no. 3, p. 223-228, fig., table, March 1961, 5 refs.

The graptolite faunas of the Poultney slate [New York - Vermont] are Early and Middle Ordovician in age. Four zonal assemblages are recognized in the formation as well as elements of others. The zonal sequence is identical to that in the lower part of the Ordovician succession in the Marathon region, Texas, and it indicates that deposition was continuous in the northern part of the Taconic area for all of the early part of the Ordovician. This is the first record of the earliest Ordovician graptolite zones in the eastern part of the United States.--Auth.

3-1835. MacNeil, F. Stearns. TERTIARY AND QUATERNARY GASTROPODA OF OKINAWA: U.S. Geol. Survey, Prof. Paper 339, 148 p., 17 figs., 21 pls. (2 in pocket), 1960, 135 refs.

The general geology of the Ryukyu Islands is summarized as a background to the discussion of the stratigraphy of the fossiliferous Tertiary and Quaternary rocks. The following stratigraphic units are recognized; the Shimajiri formation, consisting of the Yonabaru clay member (late Miocene) in the lower part of the exposed section, and the Shinzato tuff member (Miocene or Pliocene) in the upper part; and the Ryukyu group, consisting of, in ascending order, the possibly contemporaneous Nakoshi sand (Pliocene) and Chinen sand (Pliocene), the Naha limestone (Pliocene), the Yontan limestone (Pleistocene), and the Machinato limestone (Pleistocene). Raised beach deposits (post-Pleistocene) are not discussed in this report. One well on Okinawa penetrated about 2,500 ft. of the Shimajiri formation not exposed at the surface. The unexposed part of the formation is not named.

A total of 333 species, subspecies, and varieties are treated systematically. The number of species obtained from each rock unit is: Yonabaru clay member of the Shimajiri formation 118, Shinzato tuff member of the Shimajiri formation 91, Chinen sand 71, Nakoshi sand 28, Naha limestone 55, Yontan limestone 46. Ninety-seven species, 6 subspecies, and one variety are described as new. Six new genera and one new subgenus are described: *Tostatrochus*, *Loochooia*, *Nihonophos*, *Unedogemmula*, *Pinguigemmula*, *Nihonia*, and *Alticlavatula* (subgen. of *Clavatula*). The present treatment of *Makiyamaia* may be its first valid usage. It is a manuscript name of Kuroda's which was used in a plate legend by Kira in combination with a specific name but no other explanation. According to present rules this does not validate the name.

An analysis is made of the geographical relationships of the fauna of each formation to determine possible climatic changes in the area. In general, progressive cooling took place from Miocene to early Pliocene time, followed by warming in middle or late Pliocene time. The Pleistocene deposits represent warm stages.

Bathymetric interpretations based on dredging and collecting records for surviving representatives or close relatives of the fossil species indicate that the Yonabaru clay and Shinzato tuff members of the Shimajiri formation were deposited in moderately deep water - at least 150 to 300 fathoms, and 200 to 400 fathoms, respectively. The Shimajiri formation probably represents deposition on the side of a trench corresponding to the present Ryukyu trench. The Chinen sand appears to have been deposited in water between 50 and 100 fathoms deep, the Nakoshi sand in less than 50 fathoms. The Naha limestone has an indicated depth of about 20 to 30 fathoms, suggesting that it is either a lagoon deposit or an insular shelf deposit. The Yontan limestone is mostly a shallow reef detritus, probably deposited in water 10 fathoms deep or less.--Auth.

3-1836. Knox, Sanka. 3 JERSEY BOYS FIND UNIQUE FOSSIL: New York Times, v. 110, no. 37,691, p. 35, col. 5-7, 2 illus., Apr. 4, 1961.

The skeleton of a new Jurassic soaring reptile, possibly the first vertebrate to fly, has been recovered from the Granton Quarry, North Bergen, New Jersey. The specimen, about 7 1/2 in. long and embedded in a black shale matrix, has been loaned to the American Museum of Natural History, New York City, for study.--M. Russell.

3-1837. Moore, Robert, and Halsey W. Miller, Jr. A DINOSAUR-BEARING SECTION OF CRETACEOUS ROCKS IN THE EMPIRE MOUNTAINS, PIMA COUNTY, ARIZONA: Arizona Geol. Soc., Digest, v. 3, p. 57-61, fig, 1960, 3 refs.

The complete right femur and fragments of the left femur of a tentatively designated Upper Cretaceous hadrosaur are described. They were found in mainly nonmarine shales and sandstones near Empire Mountain 40 mi. SE. of Tucson, Arizona. A partial stratigraphic section is given.--M. Russell.

3-1838. Farrand, William R. FROZEN MAMMOTHS AND MODERN GEOLOGY: Science, v. 133, no. 3455, p. 729-735, illus., map, chart, table, March 17, 1961, approx. 30 refs.

Frozen mammoths of last interglacial and last glacial age have been found, sometimes in a good state of preservation. The cadavers represent healthy and robust animals, adapted to life in a boreal climate. The stomach contents and enclosing drift deposits indicate a high-boreal to tundra floral assemblage. The preserved animals probably died by asphyxiation after being trapped in bogs, landslips, mudflows, etc.. Vegetable fragments in the mouths and stomachs indicate that this probably happened during the warmer summer period. The carcasses partially decayed prior to freezing and final burial. Reports of banquets of mammoth flesh are, therefore, untrue. It is unlikely that the animals met death in a catastrophic climatic change.--F. P. Glasser.

3-1839. Cole, W. Storrs, UPPER EOCENE AND OLIGOCENE LARGER FORAMINIFERA FROM VITI LEVU, FIJI: U.S. Geol. Survey, Prof. Paper 374-A, p. A1-A7, map, 3 pls., table, 1960, 18 refs.

Eight species of large Foraminifera from Tertiary b (upper Eocene) sediments and 3 species from Tertiary c (Oligocene) limestone of Viti Levu, Fiji, are discussed and 9 of the species are illustrated. The Tertiary b fauna is identical with described faunas from Indonesia, Eua, Tonga, Saipan Island, and the Eniwetok drill holes. The Tertiary c fauna is similar to ones from Gross Kei, Moluccan Islands, and northeastern Borneo. As the earliest known deposits of Viti Levu previously had been assigned to Tertiary e (Miocene) these faunas not only establish the presence of older sediments on this island, but also provide important connecting links in the geographic distribution of the upper Eocene and Oligocene faunas of the Indo-Pacific area.--Auth.

3-1840. Andrews, Henry N., Jr. STUDIES IN PALEOBOTANY. With a Chapter on Palynology, by Charles J. Felix: 487 p., illus., New York, John Wiley, 1961, refs.

The primary theme of this introductory textbook is the evolution of vascular plants from the time they first appeared, focusing on fossil groups that have a bearing on the origin of modern ones. The material is organized according to the philosophy that the evolutionary sequence in plants began with the psilophytes and followed through with the coenopterid ferns, pteridosperms, and angiosperms. There is good reason to indicate that certain pteridophytic lines, such as the lycopods and articulates, do not fit into this general trend, and some gymnospermous groups quite certainly could not have led to the flowering plants. Some aspects of paleobotany are most effectively handled by a floristic or geographical approach. There is a special fascination about polar floras, which have violent contrasts that make a strong appeal to human nature; thus although fossil plants from the arctic zone are brought into many chapters, there is a separate account of the topic. Some of the more important late Paleozoic and Mesozoic floras of the Asiatic and southern regions are reviewed in a separate chapter. Research in this general paleobotanical province is going ahead very rapidly, and textbooks of the future will undoubtedly devote greater attention to it. Fossil pollen and spore studies constitute a clear branch of paleontology, and a separate chapter is devoted to it. Finally, an outline of certain of the most useful paleobotanical techniques is included.--M. Russell.

3-1841. Sangster, A.G., and Hugh M. Dale. A PRELIMINARY STUDY OF DIFFERENTIAL POLLEN GRAIN PRESERVATION: Can. Jour. Botany, v. 39, no. 1, p. 35-43, illus., graphs, table, 1961, 7 refs.

Samples of pollen of 3 genera (Populus, Pinus, and Typha) which are normally shed at different times during the growing season were placed concurrently in 4 habitats (a pond, a lake, a swamp, and a bog). Their decomposition was traced through the summer and autumn of 2 seasons. The study shows that there is considerable variability in fossilization of pollen under identical conditions, and that the decomposition of the same pollen is dependent on the habitat which affects not only the rate of decomposition but also the processes involved.--Auth.

3-1842. Gray, Jane. MICROPALEOBOTANICAL RESEARCH ON THE LATE TERTIARY SEDIMENTS OF ARIZONA: Arizona Geol. Soc., Digest, v. 3, p. 145-150, fig., 1960, 4 refs.

A search for fossil pollen was made to establish a chronology for late Tertiary sediments in Arizona. However, except for small amounts of poorly preserved pollen from several localities and one rather diversified and well-preserved microflora, the search was almost fruitless. The location, composition, and preliminary interpretation of pollen floras from the Safford Valley, Tonto basin, and Prescott are given. In the early Pleistocene, the Safford Valley supported a pine forest with occasional fir and possibly spruce. The Pliocene vegetation of the Tonto basin was a woodland-savanna community, dominated by pine. The flora and climate of the Prescott area in early Pliocene differed little from the present.--M. Russell.

3-1843. Davis, Margaret B. THE PROBLEM OF REBEDDED POLLEN IN LATE-GLACIAL SEDIMENTS AT TAUNTON, MASSACHUSETTS: Am. Jour. Sci., v. 259, no. 3, p. 211-222, fig., pl., table, March 1961, 29 refs.

The occurrence of pollen of tree genera not found in the modern flora of the United States and Canada in late-glacial sediments from the Williams Street bog near Taunton, Massachusetts, is considered evidence of contamination of the sediments with secondary pollen rebedded from pre-Quaternary deposits. Nearby varved clays also contain these pollen types, and because the local till contains little if any pollen, it is concluded that the secondary pollen was carried in glacial meltwater from the vicinity of Tertiary deposits 25 mi. to the NE. The late-glacial bog sediments were apparently contaminated either directly by meltwater streams, or through the erosion and redeposition of meltwater stream deposits. As the secondary pollen spectrum cannot be determined with certainty, it is impossible to interpret the mixed secondary and primary pollen spectrum contained in the late-glacial sediments.--Auth.

3-1844. Wood, Paul A. PALEONTOLOGICAL INVESTIGATIONS IN THE 111 RANCH AREA: Arizona Geol. Soc., Digest, v. 3, p. 141-143, 1960, 6 refs.

The Pleistocene Blancan and early Irvingtonian fauna of the 111 Ranch area SE. of Safford, Arizona, includes horses, rodents, edentates, gastropods, and diatoms. The horse fauna permits definitive age determinations within the local sequence. The presence of voles or lemmings suggests a cooler wetter climate than now, but the presence of Dipodomys indicates insufficient rainfall to support trees, less than 20 in. per year perhaps.--M. Russell.

6. GEOPHYSICS

See also: Geomorphology 3-1775; Structural Geology 3-1796; Fuels 3-2053.

3-1845. THE NEW PORTRAIT OF OUR PLANET: Life, v. 49, no. 19, p. 74-101, 15 figs. incl. col. illus., col. maps, Nov. 7, 1960.

Maps of the 4 quadrants of the earth and the 2 polar areas detail the topographic relief under the oceans and ice caps. The major findings relating to solid earth geophysics of the International Geophysical Year are popularly summarized; these include earthquakes, submarine volcanoes, structure of the crust and mantle, and a review of the various theories of the earth's structural history.--M. Russell.

3-1846. IGY World Data Center A. SEVENTH 6-MONTHLY CATALOGUE OF DATA IN IGY WORLD DATA CENTER A. DATA RECEIVED BY WDC-A DURING THE PERIOD 1 JULY 1957-31 DECEMBER 1960: Its: IGY Gen. Rept. no. 13, 229 p., tables, Jan. 1961, refs.

In accordance with the recommendations of the Third Meeting of CSAGI, Brussels, 1955, 3 World Data Centers were established to maintain collections of IGY data. The 3 centers are called A, B, and C. IGY World Data Center A is located in the United States; Center B is located in the U.S.S.R.; Center C consists of 21 subcenters located in 8 nations of Western Europe, in Australia, and in Japan. In addition, there are 7 previously existing Permanent Services operating in conjunction with the IGY World Data Centers.

The office of the Director of the IGY World Data Center A is located in the National Academy of Sciences, Washington, D.C. The U.S. National Committee for the IGY believed that the interests of science would best be served by housing data for the various disciplines in institutions which had a history of interest and competence in the appropriate geophysical discipline. World Data Center A was therefore divided into 11 subcenters.

It is the fundamental responsibility of each World Data Center to collect a complete set of data (in accordance with CSAGI agreements concerning the form in which data are to be collected) for the field or disciplines for which it is responsible. World Data Centers are further responsible to each other to ensure that data received by one Center are provided to all appropriate Centers. To aid in this exchange between Data Centers and to make the collections of data in the WDC's known to the scientific world, 6-monthly catalogues of data in the WDC's have been prepared since Jan. 1958. At its first meeting, the Comité International de Géophysique (CIG - successor to CSAGI) recommended that WDC's continue to prepare and distribute cumulative 6-monthly catalogues of IGY and IGC-59 data.--From introd.

This seventh catalogue supersedes previous catalogs. It contains a table of locations of IGY World Data Centers and data on the following subjects: airglow and ionosphere, aurora, cosmic rays, geomagnetism, gravity, seismology, glaciology, longitude and latitude, meteorology and nuclear radiation, oceanography, rockets and satellites, solar activity.

3-1847. Fedynsky, V.V. GEOPHYSICAL RESEARCHES IN MARINE GEOLOGY: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 6, p. 1-12, 7 figs. incl. map, pub. 1961, 28 refs.

Geophysical investigation of the structure and development of the earth's crust in ocean areas is one of the most important tasks of marine geology. In addition to the general investigation in remote parts of the ocean, in the areas of the continental shelf more detailed geophysical work is being done in searching and prospecting for oil deposits, sometimes in connection with the solution of problems in engineering geology. This article describes the status and the prospects of magnetic, gravitational, electrical, and seismic prospecting in the sea and cites examples of such work being done in the U.S.S.R.--Auth.

3-1848. Pemberton, Roger H. COMBINED GEOPHYSICAL PROSPECTING SYSTEM BY HELICOPTER: Mining Engineering, v. 13, no. 1, p. 32-36, illus., maps, graphs, Jan. 1961.

The helicopter, outfitted with magnetic, electromagnetic and radioactivity recording equipment, unmistakably represents a very advanced and efficient aerial geophysical prospecting tool. The designers of this equipment have been successful in overcoming a large number of the problems which were encountered previously in other airborne geophysical surveys. These problems, in the main, have been: 1) the great need to be able to obtain responses across the entire conductivity-size band, 2) the need to have coincident and simultaneous recordings of both the magnetic and electromagnetic responses on the same record, 3) the need for better resolution of the electromagnetic and magnetic results than it has previously been possible to achieve at higher altitudes, and 4) greater control of the positioning of the data so that subsequent ground follow-up work on any of the recorded anomalies would be at a minimum.

In spite of these necessary improvements, a number of limitations to the employment of this system and the interpretation of the recorded data still exist. As with any other type of electromagnetic equipment, the Canadian Aero/Newmont EM system is still only capable of exploring to a finite depth. This maximum depth of exploration figure appears to be about 350 ft. sub-helicopter. The electromagnetic system would therefore be incapable of locating buried conductors which do not persist to within 200 to 250 ft. of the surface. As such it would not be feasible to employ this method in areas where the depth of oxidation is in excess of this figure. This necessarily rules out many parts of the world, such as most of the southwestern states, many of the Caribbean countries and other places where the original metallic minerals have since been oxidized so that they presently exist in the form of sulfates, oxides, etc.

Even in areas such as the Precambrian Shield of Canada and other shield areas where oxidation is nonexistent or at a minimum, the inherent ambiguities in the interpretation of any geophysical data still exist. It is believed, however, that having available 3 different types of physical property data (i. e., magnetic, electrical, radioactivity) aids to an appreciable extent in resolving the ambiguities.--Auth. summ.

3-1849. Bouška, J., and others. GEOMAGNETIC CHARTS OF CZECHOSLOVAKIA FOR THE 1958.0 EPOCH: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 6, p. 529-534, 6 figs., pub. 1961, 30 refs.

The data presented here give the complete picture of the main characteristics of geomagnetic field in Czechoslovakia and serve as the basis for geomagnetic operations in prospecting and in solving a very actual problem - the construction of aeromagnetic charts for Czechoslovakia.

Compilation of the state geomagnetic charts for Czechoslovakia for the epoch of 1958.0 fulfills the IGY program for Czechoslovakia.--Auth. concl.

3-1850. Konaev, V.V., and T.A. Martynova. THE MAGNETIC SUSCEPTIBILITY OF FERROUS QUARTZITES OF THE STAROOSKOLSK IRON ORE REGION OF THE KURSK MAGNETIC ANOMALY: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 7, p. 660-666, 7 figs., 3 tables, pub. 1961, 6 refs.

The mineralogical composition of quartzites, depending principally upon the conditions of sedimentation, affects the magnitude of the magnetic susceptibility. Quartzites are divided according to the average values of the magnetic susceptibility: a) magnetite - the most magnetic; b) hematite-magnetite and cummingtonite-magnetite - somewhat less magnetic; c) barren, which are only slightly magnetic.

The difference in the mineralogical composition of hematite-magnetite and cummingtonite-magnetite samples is not reflected in the values of the magnetic susceptibility.

The degree of heterogeneity of the magnetic susceptibility of quartzites in the various districts is governed by the particularities of the geological structure and by the tectonic processes. In districts where a great crumpling of the strata is observed and where the intrusive activity is manifested more intensively, the variation curves for κ are more uniform.

The magnetic susceptibility increases when the content of magnetite increases and when the grain size of the latter increases.

The like direction of the 2 processes – sedimentary accumulation connected with the increase in the magnetite, and the increase in the degree of metamorphism, connected with the increase in the size of the magnetite grain – do not permit the authors to declare definitively to which of these processes they must give priority in explaining the increase in magnetic susceptibility when passing from W. to E. However, a number of indirect considerations lead them to believe that, in all likelihood, the processes of metamorphism play a decisive role in the increase of κ.

Oxidized quartzites differ markedly in the magnitude of κ from the first 3 groups. Between the oxidized quartzites, composing the upper part of the strata, and the quartzites not affected by weathering processes, there is quite a clear boundary or, at the very least, a narrow transitional zone from the first to the latter. Low-magnetic quartzites of group 4 do not interfere with the separation of the oxidation zone, since they are represented by units of slight thickness.--Auth. concl.

3-1851. Irving, E. PALEOMAGNETIC METHODS: A DISCUSSION OF A RECENT PAPER BY A. E. M. NAIRN: Jour. Geology, v. 69, no. 2, p. 226-231, 2 figs., March 1961, 11 refs.; Reply, by A. E. M. Nairn, p. 231-235, 2 figs., 2 tables, 13 refs.

Discussion of GeoScience Abstracts 2-1720.

3-1852. Linkova, T.I. PALEOMAGNETIC STUDIES OF DEVONIAN SEDIMENTARY LAYERS IN THE NORTHWEST OF THE RUSSIAN PLATFORM: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 6, p. 575-577, 3 tables, pub. 1961, 5 refs.

The following conclusions can be drawn. 1) Rocks of the middle Paleozoic have both normal and reversed magnetization. 2) The coordinates for the N.-seeking magnetic pole found for the N and R magnetized samples are roughly the same. 3) The coincidence of the polar coordinates obtained in the present work with those obtained by other authors at different times and for regions sufficiently far apart indicate that the European paleomagnetic data are reliable.--Auth. concl.

3-1853. Sullivan, Walter. SCIENTISTS TOLD OF A-TEST CLUES: New York Times, v. 110, no. 37,692, p. 16, col. 4-6, Apr. 5, 1961.

A detectable variation in the normal, albeit weak, flow of electric currents through the earth's crust caused by some unrelated but violent electrical disturbance has been suggested as a possible means of monitoring for buried nuclear explosions.--M. Russell.

3-1854. Volarovich, M.P., and A.T. Bondarenko. A STUDY OF ELECTRICAL RESISTANCE IN SAMPLES OF ROCKS AT ALL-AROUND PRESSURE UP TO 1000 kg cm^2: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 7, p. 631-635, 8 figs., table, pub. 1961, 17 refs.

Methods were devised for studying the electrical resistance of samples of rocks enclosed in a bitumen coating under all-around pressures up to 1,000 kg./cm^2.

The electrical resistance and polarization were measured at pressures up to 1,000 kg./cm.^{2} for sedimentary rocks - shale, sandstone, arenaceous marl, calcareous sandstone, fine-arenaceous clay; for igneous rocks: basalt, diabase, and also for a deep rock - peridotite.

When the all-around pressure is increased to 1,000 kg./cm.^{2} the electrical resistance of various rocks (for residual current) is reduced by 18-74%.

The polarization of rocks was determined at atmospheric pressure at 1,000 kg./cm^2. When the pressure is increased the polarization drops considerably. For various rocks at different electrical voltages, it is reduced by 5-98 v when the pressure is increased to 1,000 kg./cm^2.

The true specific resistance of rocks under consideration was calculated by taking into account polarization. At 1,000 kg./cm.^{2} it is 17-92% less than resistance found from residual current.--Auth. concl.

3-1855. Dyakonov, B.P. ASYMPTOTIC EXPRESSIONS FOR ELECTROMAGNETIC FIELDS CAUSED BY A CYLINDRICAL INHOMOGENEITY: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 7, p. 636-638, pub. 1961, 3 refs.

Asymptotic representation of anomalistic electromagnetic fields for a massive cylindrical inclusion at a considerable depth is obtained from the solution of the diffraction problem of electromagnetic waves on a circular cylinder located in a homogeneous and isotropic half space. The vertical component of the magnetic anomalistic field was found to decrease along the surface of the earth as $1/y^3$, while the electric component and the horizontal component of the magnetic anomaly decrease along the same surface as $1/y^2$, y being the coordinate across the axis of the cylinder.--A.J. Shneiderov (courtesy Geophysical Abstracts 183-226).

3-1856. Kozulin, Yu. N. ON THE THEORY OF ELECTROMAGNETIC FREQUENCY SOUNDING OF MULTILAYERED STRUCTURES: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 8, p. 798-803, 3 figs., pub. 1961, 10 refs.

The existing rigorous methods for computing electromagnetic fields in layered media are either formal solutions from which no physical information can be derived, or require the use of high-speed computers. It is thus necessary to develop simplified (approximation) methods of computation.

Our "effective-field" method, which compares the actual field excited in a layered half-space with the field in a fictitious homogeneous half-space having a frequency-dependent conductivity enables us to derive very simple approximate formulas for calculation.

The new method is used to perform certain calculations and to suggest a principle that can be followed in constructing templates for interpreting geoelectric measurements.

The proposed technique of interpretation is also extremely simple, so that we may expect its rapid acceptance for geoelectric investigations.--Auth. concl.

3-1857. Gluzmann, A.M., and N.A. Plokhikh. SOLUTION OF SOME TWO-DIMENSIONAL PROBLEMS IN ELECTRICAL PROSPECTING: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 7, p. 667-670, 5 figs., pub. 1961, ref.

The cases of geoelectric anomaly fields of a linear electrode located on the surface of the earth over a vertically layered medium, over a dipping interface of 2 different layers, and over a conducting semicircular cylinder are treated mathematically. Solutions for the components of the normal fields and the potentials at a given point are provided for the above cases. A bilogarithmic master chart is given for determination of the thickness of the cap layer and the resistance of the basement rock from the potential gradient curves of a profile across the strike.--A.J. Shneiderov (courtesy Geophysical Abstracts 183-233).

3-1858. Dmitriev, V. I. A SOLUTION OF A BASIC PROBLEM IN THE THEORY OF THE INDUCTION METHOD OF ELECTROMAGNETIC SURVEYING: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 8, p. 748-753, 4 figs., pub. 1961, 4 refs.

A rigorous solution is obtained for the problem, basic in the theory of the induction method of electromagnetic surveying, of the diffraction of an electromagnetic field at a perfectly conducting half-plane lying in a homogeneous, conducting half-space.--Auth.

3-1859. Mizyuk, L.Ya. METHODS AND APPARATUS FOR AIRBORNE ELECTRICAL PROSPECTING: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 6, p. 522-528, 4 figs., pub. 1961, 13 refs.

Various methods of airborne electrical prospecting are discussed. In some of these an electromagnetic field is artifically excited by a source on the ground, in others by a source travelling through the air. The apparatus is described and the various methods are analyzed so as to compare the possibilities they offer for discovering field anomalies caused by variations in the electrical conductivity of rocks. An account of test results is given.--Auth.

3-1860. Pfluke, John H. AGADIR EARTHQUAKE OF FEBRUARY 29, 1960 - SEISMICITY AND GEOLOGY OF THE AREA: Seismol. Soc. America, Eastern Sec., Earthquake Notes, v. 31, no. 4, p. 46-50, 2 figs., Dec. 1960, 3 refs.

On Feb. 29, 1960, a major earthquake destroyed the city of Agadir, Morocco. The epicenter was located at 30°27'N. 9°37'W. Although Morocco is not an area of great seismic activity, a number of destructive earthquakes have occurred. Agadir is located on the coast, just S. of the axis of the High Atlas. Structural geology of this area is briefly described.

The Agadir earthquake occurred in a well-defined belt of earthquakes that extends the length of Morocco. This belt is a branch of the large Alpide belt which forms a loop about the western Mediterranean. The fault break which caused the Agadir earthquake may have occurred at some point on a downward extention of either the Casbah fault or the fault of Tildi. The fracture was probably in the vicinity of the Casbah fault, since in this locality the earthquake was of intensity XI (Modified Mercalli scale) while that section of the city near the fault of Tildi suffered intensities of only IX or X.--A. C. Sangree.

3-1861. Solonenko, V. P. THE GOBI ALTAI EARTHQUAKE OF DECEMBER 4, 1957: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 7, p. 26-32, 4 illus., map, pub. 1961.

On Dec. 4, 1957, at 3:39 A.M. Greenwich time, one of the strongest earthquake shocks in the world during the last half century shook the Gobi Altay. Its intensity (M) was measured as 7.75 to 8.6 by stations in various countries; i.e., between 11 to 12 on the international scale. Although the estimate of the earthquake's intensity at 12 is exaggerated, it should be noted that its local effects corresponded to those which classify an earthquake as a "world catastrophe." These effects included the collapse of the Ikhe-Bogdo mountains whose crest stands 3,957 m. above sea level, the formation of a graben between the Bakhar-Ula and Tsetsen-Ula mountains, the formation of a complex overthrust between the Ikhe-Bogdo and Baga-Bogdo mountains, and the uplift of the Gobi Altay and easterly shift of 2.8 to 3.5 m. along a 250 km. stretch. Locally, the amount of displacement appears to approach tens of meters according to preliminary data from aerial negatives. --Auth.

3-1862. Bulin, N. K. DETERMINATION OF THE DEPTH OF THE FOLDED BASEMENT WITH THE AID OF TRANSMITTED EXCHANGE WAVES OF TYPE PS RECORDED IN EARTHQUAKES: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 6, p. 518-521, 2 figs., 3 tables, pub. 1961, 10 refs.

The possibility is shown of identifying on seismograms of stations of a general type the transmitted exchange wave, PS, which is generated in an earthquake at the surface of the folded basement. Results are presented of the determination of depth of this boundary from seismograms of local and distant earthquakes, registered by the station "Bairam-Ali."--Auth.

3-1863. Bogert, Bruce P. AN OBSERVATION OF FREE OSCILLATIONS OF THE EARTH: Jour. Geophys. Research, v. 66, no. 2, p. 643-646, 3 figs., table, Feb. 1961, 6 refs.

The more extensive measurements by Benioff, Press, and Smith, by Ness, Harrison, and Slichter, and by Alsop, Sutton, and Ewing are supported by the results of spectral power analyses, using an electronic computer, of seismograms obtained of the Chilean earthquake of May 1960, by a Columbia long-period vertical seismometer installed at Chester, New Jersey. Agreement is particularly good in the shorter period range (up to 17.7 min.). It is suggestive that peaks at 20.4 and 10.06 min. correspond to the lowest purely radial mode ${}_0S_0$ and the next lowest mode ${}_1S_0$, respectively.--D. B. Vitaliano.

3-1864. Willis, David E. SOME OBSERVATIONS ON THE ATTENUATION OF SEISMIC WAVES: Seismol. Soc. America, Eastern Sec., Earthquake Notes, v. 31, no. 4, p. 37-45, 5 figs., Dec. 1960, 5 refs.

A number of quarry blasts were recorded on magnetic tape using low-frequency seismometers. Spectral analyses were performed on these recordings using variable pass-band filters. Empirical equations involving geometrical spreading plus an appropriate absorption factor were found to fit observed attenuation. Examples are presented showing the effect of various parameters on the spectra of seismic waves generated by these blasts.--Auth.

3-1865. Volarovich, M. P., and others. INVESTIGATION OF THE ATTENUATION OF ELASTIC WAVES IN ROCK SPECIMENS: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 8, p. 793-797, 7 figs., pub. 1961, 41 refs.

A device is developed for the investigation of the attenuation of elastic ultrasonic waves in rock specimens of small size, intended for conduction experiments made under conditions of high uniform pressures.

A method of determining the amplitude coefficient of attenuation is developed by the use of multiple reflections of ultrasonic pulses of a certain frequency in specimens which have a cylindrical shape.

Values are obtained for the attenuation coefficient of longitudinal ultrasonic waves in some rock specimens.--Auth. concl.

3-1866. Kovalev, O. I., and L. V. Molotova. BOREHOLE PERCUSSION DEVICE FOR THE EXCITATION OF VARIOUS TYPES OF ELASTIC WAVES: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 7, p. 639-646, 11 figs., pub. 1961, 18 refs.

A borehole percussion device (BPD) is developed and tested under field conditions, making this device one of the first attempts to place in the borehole a source which excites transverse waves. The borehole percussion device was placed at a depth of up to 10.5 m. and was operated from the surface during testing.

The performance of the BPD is analogous to the effect of a horizontal force oriented in the required direction. Three types of waves are originated by this device: P, SV, and SH. The frequencies of the excited oscillations become higher as the depth of the percussion increases.

BPD can be used for the study of velocities of elastic waves P, SV, and SH in the upper portion of the profile (within the limits of a few tens of meters) as a function of direction and depth. It is also possible to utilize BPD in the study of the absorption coefficients of longitudinal P and transverse SH and SV elastic waves.

In field tests of the BPD the velocity values of 3 types of volume waves were determined. In particular, it was established that in dry or slightly moist loessy sandy clays the velocities of the P, SV, and SH waves do not depend on the direction, whereby $v_{SV}=v_{SH}$ (medium is isotropic). The magnitude of the ratio v_P/v_S in these rocks (up to a depth of the order of 10 m.) is characterized by very small values: 1.45 - 1.70. In the depth intervals from 10 to 30 m. the parameter $\underline{v}_P/\underline{v}_S$ on an average is equal to 3.0.--Auth. concl.

3-1867. Radzhabov, M. M. SELECTION OF AVERAGE VELOCITIES IN DETERMINING EFFECTIVE DEPTHS FROM SINGLE TRANSVERSE TRAVEL-TIME CURVES OF REFRACTED WAVES: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 6, p. 571-574, 3 figs., pub. 1961, 5 refs.

On the basis of the functional relation $\overline{v}=\overline{v}(H)$ a method of determining effective depths in the zone of emergence from single transverse travel-time curves of refracted waves is described for the case of change of average velocity with depth.

It is shown that nomograms of the form

$$t_{o_{refr}} = t_{o_{refr}}(H) \text{ and } \overline{v}=\overline{v}(H)$$

for interpretation of longitudinal travel-time curves of refracted waves by the method of differences of t_0 can also be used for determining effective depths from transverse travel-time curves of refracted waves.

The method was widely tested in the interpretation of data obtained in working with the correlation method of refracted waves on transverse profiles in western regions of central Asia.

Seismic profiles, constructed by means of calculating the effective depths with a consideration of the given dependence $\overline{v}=\overline{v}(H)$, agree sufficiently well with cross-sections obtained from data of the method of refracted waves and from the data of drilling.--Auth. concl.

3-1868. Shamina, O. G. AN INVESTIGATION OF THE DYNAMIC FEATURES OF LONGITUDINAL WAVES IN LAYERS OF DIFFERENT THICKNESS: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 8, p. 754-760, 9 figs., pub. 1961, 7 refs.

The dynamic features of longitudinal pulse waves are investigated in a free layer and in a layer immersed in water. It is shown that the velocity, form, dominant period and attenuation of a sliding wave in a free layer and a head wave from a layer in water are dependent on the thickness of the layer. The thinner the layer, the less will be the distance from the radiator within which it can be treated as a plate. The behavior of the wave amplitude is the most reliable indication that a longitudinal wave propagated in a layer with a velocity equal to the velocity in the plate is fully formed.--Auth.

3-1869. Molotova, L. V., and Yu. I. Vassilev. ON THE VALUE OF THE RATIO OF THE VELOCITIES OF LONGITUDINAL AND TRANSVERSE WAVES IN ROCKS. I: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 7, p. 621-630, 11 figs., pub. 1961, 62 refs.

Some new methods are suggested for the determination of the value of the ratio of $\underline{v}_P/\underline{v}_S$ of longitudinal and transverse waves in rocks under the conditions of their natural occurrence. These methods are based on a simultaneous processing of the travel-time curves of the refracted longitudinal and exchange waves.

Some results are adduced of the determination of the parameter of $\underline{v}_P/\underline{v}_S$ for various rocks (soil, weathered clays, sandy-clayey formations, dense limestones, crystalline rocks) with different depths (from 0 to several kilometers) from the observational data obtained in various areas. The analysis of the above results permits the following conclusions.

1) There is no indication of any direct relationship between the value of $\underline{v}_P/\underline{v}_S$ and the velocity of the longitudinal waves $\underline{v}_P$ for various rocks. The same values of $\underline{v}_P/\underline{v}_S$ may correspond to both large and small values of $\underline{v}_P$.

2) A seismic zone of low velocities consisting of dry terrigenous rocks is characterized by low values of v_P/v_S (1.7 - 1.8). There were previously conflicting opinions with regard to this question. The above-mentioned values are close to the values of $\underline{v}_P/\underline{v}_S$ in dry sand in laboratory determinations.

3) For sandy-clayey and clayey, both weathered and slightly weathered rocks, the value of $\underline{v}_P/\underline{v}_S$ increases with an increase of $\underline{v}_P$ and $\underline{v}_S$, i. e., with an increase in the cohesity and, apparently, the soil moisture. Thus, for weathered clayey formations (observations in the wall of a precipice) the velocities of longitudinal and transverse waves $\underline{v}_P$ and $\underline{v}_S$ are 400 and 220 m./sec. respectively; $\underline{v}_P/\underline{v}_S=1.8$; for slightly-weathered sandy-clayey formations, not bared by any outcrop, $\underline{v}_P=1{,}100$ m./sec., $\underline{v}_S=460$ m./sec., $\underline{v}_P/\underline{v}_S=2.4$; for a complex of nonweathered sandy-clayey formations with a depth up to 250 - 300 m., $\underline{v}_P=2{,}500$ m./sec., $\underline{v}_S=1{,}000$ m./sec., $\underline{v}_P/\underline{v}_S=2.4-2.6$.--Auth. concl.

3-1870. Molotova, L. V., and Yu. I. Vassilev. VELOCITY RATIO OF LONGITUDINAL AND TRANSVERSE WAVES IN ROCKS, II: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 8, p. 731-743, 7 figs., 2 tables, pub. 1961, 74 refs.

The dependence of parameter $\underline{v}_p/\underline{v}_s$ on the frequency in heterogeneous media is analyzed. It is shown that in a 2-component heterogeneous medium the value of $\underline{v}_p/\underline{v}_s$ changes nonmonotonously (a case of harmonic oscillations). It fluctuates near the value of $\underline{v}_{p\infty}/\underline{v}_{s\infty}$, which corresponds to waves of infinitely high frequency, and approaches this value gradually as the frequency increases. The value of $\underline{v}_{p\infty}/\underline{v}_{s\infty}$ is equal to the velocity ratio of the longitudinal and transverse waves in a layered medium as computed from the mean velocity formula in geometrical seismics. The relationship between $\underline{v}_{p_0}/\underline{v}_{s_0}$ for low-frequency waves and $\underline{v}_{p\infty}/\underline{v}_{s\infty}$ for high-frequency waves may vary; however, neither "ultra-low" nor "ultra-high" values of $\underline{v}_{p_0}/\underline{v}_{s_0}$ and $\underline{v}_{p\infty}/\underline{v}_{s\infty}$ are possible. The differences between the maximum and minimum values of $\underline{v}_p/\underline{v}_s(\omega)$ are greater than those between $\underline{v}_{p_0}/\underline{v}_{s_0}$ and $\underline{v}_{p\infty}/\underline{v}_{s\infty}$. However, even they are relatively small in most cases which allows us to compare the $\underline{v}_p/\underline{v}_s$ values in first approximation in generalizing the experimental data for nonhomogeneous media, under disregard of their dependence on the frequency at which they had been obtained.

Generalization of a large volume of experimental data indicated that the $\underline{v}_p/\underline{v}_s$ values for crystalline and metamorphic rocks occurring at various depths fall in most cases into a narrow interval: 1.7 to 1.9. The $\underline{v}_p/\underline{v}_s$ values for sedimentary rocks, on the other hand, vary within a considerable range: 1.5 to 14.0. A definite connection exists between the limits of $\underline{v}_p/\underline{v}_s$ for sedimentary rocks and the velocities of the longitudinal and transverse waves $\underline{v}_p$ and $\underline{v}_s$ as well as the depth of occurrence. Particularly reliable experimental data on v_p/v_s were obtained for dry weathered rocks (low v_p). Their v_p/v_s values are also low (1.5 to 1.8). The interval of possible v_p/v_s values for sedimentary rocks decreases for those with high longitudinal wave velocities ($v_p > 3{,}000$ m./sec.).--Auth. concl.

3-1871. Radzhabov, M. M., and L. E. Agranovsky. DETERMINATION OF DEPTHS AND RELIEF OF AN INTERFACE BY MEANS OF SINGLE TRANSVERSE TRAVEL-TIME CURVES OF REFRACTED WAVES: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 6, p. 562-570, 9 figs., pub. 1961, 14 refs.

A case of determination of the relief of a refracting boundary of a layer having velocity v_g of seismic wave propagation and a dip angle $\phi < 15^\circ$ is considered. It is shown that the method of determination of the depth H to the refracting boundary from the individual transverse traveltime curves of refracted waves produces an error in H of less than 5% if the condition $\phi \leqslant 15^\circ$ is observed.--A. J. Shneiderov (courtesy Geophysical Abstracts 182-477).

3-1872. Ivakin, B. N. METHODS FOR CONTROLLING THE DENSITY AND ELASTICITY OF A MEDIUM DURING THE TWO-DIMENSIONAL MODELING OF SEISMIC WAVES: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 8, p. 761-771, 6 figs., pub. 1961, 38 refs.

The article examines methods for controlling the density and elasticity of thin plates (sheets) by means of a net of holes or elevations, as well as by means of fabricating a plate of variable thickness.--Auth.

3-1873. Zaitsev, L. P. ON DEGENERATED HEAD WAVES IN AN ELASTIC MEDIUM WITH AN INTERFACE: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 8, p. 744-747, 6 figs., pub. 1961, 3 refs.

The physical nature of the oscillations described has not yet found any satisfactory explanations. More definite suppositions regarding their origin may be made only after a detailed study of the wave picture in the medium on the distal side of the interface.

Degenerated head waves possess a number of peculiarities, which both help and complicate their observation. These waves should be encountered frequently during seismic observations, since for their occurrence it is sufficient that one of the velocities in a medium with a source be higher than at least one of the wave velocities in the underlying layer. Strong damping of the oscillations with increasing distance of a source or an observer from the interface may be to a great extent compensated by the observations with low frequencies. The invariability of the form of the recording at all epicentral distances, undoubtedly, may help in identifying the degenerated head waves on the seismograms.

One may expect that the observations of such waves will be useful for seismoglaciological investigations, where any other means of judging the mechanical properties of the layer with lower velocities underlying the ice is frequently absent.--Auth. concl.

3-1874. Holzmann, F. M. FREQUENCY THEORY OF THE GROUPING OF SIGNALS ON A BACKGROUND OF CORRELATED NOISES: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 6, p. 511-517, 4 figs., pub. 1961, 5 refs.

The principal properties of the x-representations of regular signals and irregular correlation noises are examined. The grouping of signals is reduced to the filtration of the suitable x-representations. The dependences of the quadratic mean amplitude of the noise at the output of the group and the resultant signal/noise ratio on the parameters of the group and also on the form of the function of the autocorrelation of the noise are also studied.--Auth.

3-1875. Rudman, Albert J. A SEISMIC REFLECTION SURVEY OF THE SURFACE OF THE BASEMENT COMPLEX IN INDIANA: Indiana, Geol. Survey, Rep. Prog. no. 18, 26 p., 7 figs., 3 pls. (1 in pocket), 2 tables, 1960.

The surface of the basement complex that underlies 5 counties in southwestern Indiana has been mapped by the reflection seismograph method. Seismic shot points were spaced 1 to 3 mi. apart along 6 traverses in Gibson, Pike, Posey, Vanderburgh, and Warrick counties. A structure map on the surface of the basement complex shows an elongate northwestward-trending depression that is as much as 22 mi. in width and that has a maximum depth of 3,500 ft. below the regional slope of the basement surface. Structure maps drawn on the surface of Devonian limestone, the Trenton limestone, and the St. Peter sandstone show a monocline over the NE. flank of this basement depression. The depression in the surface of the basement complex and the monocline shown on Paleozoic maps may be related structurally to the LaSalle anticline.--Auth.

3-1876. Biggs, Maurice E., and others. SEISMIC VELOCITIES AND SYNTHETIC SEISMOGRAM COMPUTED FROM A CONTINUOUS VELOCITY LOG OF A TEST WELL TO THE BASEMENT COMPLEX IN LAWRENCE COUNTY, INDIANA: Indiana Geol. Survey, Rep. Prog. no. 21, 15 p., 4 figs., 1960.

The Geophysics Section of the Indiana Geological Survey has analyzed a continuous velocity log of the Indiana Farm Bureau No. 1 Luther Brown test well in Lawrence County, (SE1/4 SE1/4 sec. 20, T. 5 N., R. 2 E.), for interval and average vertical velocities from the New Albany shale to the basement complex. Average vertical velocities from a datum within the New Albany shale were 13,500 ft. per sec. to the Trenton limestone, 14,900 ft. per sec. to the Knox dolomite, 16,500 ft. per sec. to the Mt. Simon sandstone, and 16,250 ft. per sec. to the basement complex.

Data from the continuous velocity log were used to compute a synthetic seismogram. Comparison of this seismogram with a field seismogram made near the well shows good correlation of reflections from the Trenton limestone, the upper and lower parts of the Knox dolomite, the Eau Claire formation, the Mt. Simon sandstone, and a metasedimentary rock unit resting on basalt that is assigned to the basement complex. Although the continuous velocity log does not show a sharp velocity contrast at the top of the metasedimentary rock unit, the synthetic seismogram demonstrates that energy reflected from a series of small velocity contrasts combine to give a prominent reflection.--Auth.

3-1877. Kogan, R M., and Sh. D. Friedmann. STUDY OF A MIXTURE OF RADIOACTIVE ELE-

MENTS BY THRESHOLD SPECTROMETERS: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 6, p. 535-539, 4 figs., pub. 1961, 5 refs.

The problem of selecting the best levels of discrimination E_i for a threshold spectrometer in analyzing a multi-component mixture is examined. As applied to studying the gamma-radiation of U-Th plates by a threshold spectrometer with an NaI(Tl) crystal the best combination of levels E_1 and E_2 is found. The question of the effect of the interfering K^{40} radiation on the selection of the best levels of discrimination is considered.--Auth.

3-1878. Friedmann, M.D ON INVESTIGATIONS OF THE GAMMA-RAY SPECTRUM OF NATURAL ROCK LAYERS: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 8, p. 786-792, 6 figs., 2 tables, pub. 1961, 16 refs.

On the basis of certain hypotheses concerning the distribution of gamma-ray sources and of absorbing media, stable parameters characterizing the spectrum of gamma rays from ~0.2 to 3.0 Mev are determined. The scope of the information obtainable when gamma-ray fields are observed by means of scintillation counters in conjunction with isotropic detectors is discussed. Special examples illustrate the possibilities of gamma-ray spectrometry of rocks in natural layers.--Auth.

3-1879. Gregory, A.F. GEOLOGICAL INTERPRETATION OF AERORADIOMETRIC DATA: Canada, Geol. Survey, Bull. 66, 29 p., 4 figs., 2 tables, 1960, 40 refs.

Distinct contrasts in gamma radioactivity exist between various materials on the surface of the earth. These contrasts may be mapped with sensitive airborne detectors. Because of the many variables involved, the interpretation of radioactivity patterns so obtained has been qualitative and very general.

The present theoretical study and its application to field measurements with integrating detectors have resulted in a new quantitative technique for the interpretation of regional geology. The theory of attenuation of gamma flux suggests that for multiple scattering conditions, certain generalizations may be made which permit a simpler assessment of flux variations than is required by the established complex mathematical treatment. The major determinants of gamma flux density are: the air distance between the source and the detector, the effective radiating area of the source, and the specific surface activity of the source material. Over large air distances, the multiple-scattered radiation approximates a state of spectral equilibrium and the attenuation of this equilibrium flux may be described by a single, effective absorption coefficient.

The signal measured over a source, with both area and thickness effectively infinite in extent, is expressed as:

$$S_h = k\frac{2\pi}{\mu_E} s_o e^{-\mu_E h}$$

where S_h is the signal intensity at altitude h above the source, S_o is the theoretical signal at the surface of an elementary unit area of source material, μ_E is the effective absorption coefficient of its equilibrium flux in air, and k is a constant.

In the interpretative technique, maximum values of signal intensity and flight altitude above ground are used to plot a lithological clearance-signal curve for each rock type in the survey area. Values of S_o and μ_E which are characteristic of the rock may be determined from these curves. Accordingly, the automatic correction of data for flight altitude, based on the assumption of a single absorption coefficient, is not valid for comparative aeroradiometry.

The lithological clearance-signal data suggest that spectral analysis of gamma radiation may provide useful data for a more detailed geological interpretation than the present technique permits.--Auth.

3-1880. Golovina, I. F., and N. N. Malov. ON THE GEYSER THEORY: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 7, p. 616-620, 2 tables, pub. 1961, 12 refs.

The mechanism of geyser action is examined. On the basis of an assumed simplified scheme, the author analyzes the activity of the Kamchatka geysers, their temperature regime, the duration of the individual cycles, etc.--Auth.

7. GEOCHEMISTRY

See also: Structural Geology 3-1794, 3-1796; Stratigraphy 3-1830; Mineralogy 3-1941; Igneous and Metamorphic Petrology 3-1961; Sedimentary Petrology 3-1989, 3-1990, 3-1992; Mineral Deposits 3-2020; Fuels 3-2052, 3-2056 through 3-2060.

3-1881. Ahrens, L.H., and S.R. Taylor. SPECTROCHEMICAL ANALYSIS. A TREATISE ON THE D-C ARC ANALYSIS OF GEOLOGICAL AND RELATED MATERIALS: 2d ed., 454 p., diags., graphs, tables, Reading, Massachusetts, Addison-Wesley Publishing Company, 1961, approx. 1,000 refs.

Books on spectrochemical analysis usually fall into one of 2 categories: those that are general and those that deal specifically with particular fields of application. The present book belongs to the second category. Spectrochemical techniques employing various methods of excitation (flame, d-c or a-c arc, spark) have been applied effectively to the analysis of a wide variety of materials, including the so-called nonconducting or nonmetallic samples such as minerals, rocks, meteorites, soil, refractories, slag, and biological ash. For the analysis of these, excitation by the d-c arc offers several advantages. This book is restricted to the use of this source, with emphasis on the naturally occurring substances - rocks, minerals (including ores), meteorites, and soils. The spectrograph has provided an enormous amount of data on the trace element content of these substances, and because of its versatility, speed, and sensitivity, it has become the most powerful single analytical tool now available for their analysis. Whereas 10 years ago the spectrographic method was often regarded as semiquantitative, now it is frequently used for the purpose of obtaining fully quantitative analytical data.

Several developments have taken place since the appearance of the first edition of this book in 1950.

In the new edition, considerable emphasis is given to 3 of them: the use of spectrochemical techniques for estimating elements at comparatively high concentrations; the development of general sensitive methods by means of which many elements may be accurately estimated in a single operation; and, finally, the use of so-called enrichment techniques to extend the detection limits by large factors.

The book is in 2 parts. Pt. 1 (Chaps. 2 through 12) covers certain theoretical aspects and the principles of qualitative and quantitative analysis. Pt. 2 is devoted mainly to discussions of the spectrochemistry of the individual elements. Considerable attention is given in the first part to those factors that require consideration when an internal standard is to be chosen. This aspect of quantitative spectrochemical analysis becomes particularly important when nonconducting powders are analysed by d-c arc excitation. The second part includes resumés of some of the methods that have been employed, with particular attention given to methods describing new techniques or providing illustrative examples of the choice of methods and of internal standards.

In Pt. 2 some comments have been made on the geochemical distribution of each element. These comments are restricted, for the most part, to occurrence in the common mineral and rock types. In addition, a table of abundances of the elements in the earth's crust is included. Such geochemical information serves to indicate which elements are likely to be detectable; it is also of use when selecting an internal standard.

Wavelength tables of the most sensitive lines of the elements as excited in the d-c arc are given as an Appendix. Arrangement in the tables is such that the wavelengths of all interfering lines to within 0.4-0.5 A may easily be scanned. Notes on observed interferences are given. The tables include a list of lines that are most sensitive visually and which may be used for spectroscopic analysis.--From pref.

3-1882. Weyl, Peter K. THE CARBONATE SATUROMETER: Jour. Geology, v. 69, no. 1, p. 32-44, 8 figs., 2 tables, Jan. 1961, 4 refs.

A new instrument, the carbonate saturometer, makes it possible to measure the degree of departure of most aqueous solutions from saturation with respect to solid carbonates. The instrument utilizes the fact that the pH of a solution changes as carbonate is added to or removed from the solution. By use of a pH-sensitive electrode and a reference electrode, the instrument measures the change in potential obtained when the solution around the pH-sensitive electrode is equilibrated with a solid carbonate.

A method has been developed to permit the absolute calibration of the instrument for any particular solution. The method utilizes a comparison between an acid-base and a sodium bicarbonate titration and does not require a chemical analysis of the solution. The calibration procedure is not invalidated by the presence of buffers in the solution. The sensitivity of the instrument for artificial sea water in the pH range from 7.5 to 8.3 is about 1 millivolt per part per million calcite.--Auth.

3-1883. Mumpton, Frederick A., and Rustum Roy. HYDROTHERMAL STABILITY STUDIES OF THE ZIRCON-THORITE GROUP: Geochim. et Cosmochim. Acta, v. 21, no. 3/4, p. 217-238, 5 figs., 4 tables, Jan. 1961, 39 refs.

The stability relations among minerals of the zircon-thorite group and the effect of related oxides on them have been studied under both "dry" and hydrothermal conditions. The problem of "hydrous" zircons and its relation to the metamict state has been investigated both experimentally and theoretically. From the data it appears that hydrous zircons and thorites do not involve OH^- substitution for O^{2-} with omission of Si^{4+}, but rather are formed by strong water adsorption in metamictized zircon and thorite. The phase equilibrium involved in the thorite-huttonite polymorphism has been studied, and it is concluded that huttonite is the only stable polymorph of $ThSiO_4$. Zircon dissociates at 1550 ± 50°C. to $ZrO_2 + SiO_2$.

The Alkemade triangles in the ternary systems ZrO_2-ThO_2-SiO_2 and ZrO_2-UO_2-SiO_2 have been determined and a not-impossible diagram is presented for the system ThO_2-UO_2-SiO_2. The extent of solid solution between $ZrSiO_4$-$ThSiO_4$, $ZrSiO_4$-"$USiO_4$" and $ThSiO_4$-"$USiO_4$" is discussed in connection with the composition of natural zircon and thorite. The application of the experimental data to natural mineral assemblages is discussed.--Auth.

3-1884. Webster, A. H., and Norman F. H. Bright. THE SYSTEM IRON-TITANIUM-OXYGEN AT 1200° C. AND OXYGEN PARTIAL PRESSURES BETWEEN 1 ATM. and 2 X 10^{-14} ATM.: Am. Ceramic Soc., Jour., v. 44, no. 3, p. 110-116, 5 figs., table, March 1961, 16 refs.

The 1,200°C. isotherm in the system Fe-Ti-O has been studied by equilibrating mixtures of iron oxide (Fe_2O_3) and titanium oxide (TiO_2) with atmospheres of controlled O partial pressure. These atmospheres consisted of CO_2, air, O, mixtures of CO_2 and H_2, and mixtures of CO_2 and CO. The resulting oxide mixtures were examined at room temperature by chemical analysis and by X-ray diffraction. The stability regions of the α-oxides ($Fe_mTi_{2-m}O_3$), of the spinels, ($Fe_nTi_{3-n}O_4$), and of the orthorhombic oxides ($Fe_pTi_{3-p}O_5$) were determined. Some nonstoichiometry occurs in the spinels and in the α-oxides. The O partial pressures at which spinel is reduced to (Fe + α-oxides) and at which α-oxide (ilmenite) is reduced to (Fe + orthorhombic oxide) were determined as 2.1×10^{-13} and 9.3×10^{-14} atm., respectively. The orthorhombic solid solution series extends over the whole range of O partial pressures studied.--Auth.

3-1885. Hinz, Wilhelm, and Peter Olaf Kunth. PHASE EQUILIBRIUM DATA FOR THE SYSTEM MgO-MgF_2-SiO_2: Am. Mineralogist, v. 45, no. 11/12, p. 1198-1210, 9 figs., 2 tables, Nov.-Dec. 1960, 15 refs.

In completely anhydrous melts of the binary system MgO-MgF_2 a simple eutectic reaction at 1214°C. was established.

The binary system Mg_2SiO_4-MgF_2 is characterized by the formation of minerals of the humite-clinohumite group. All of them show incongruent high-temperature reactions, norbergite melting with a primary crystallization of chondrodite (stable) or forsterite (metastable) at 1345°C., chondrodite melting with primary crystallization of forsterite at 1450°C. On heating, clinohumite breaks down at 1380°C. to a mixture of forsterite and chondrodite. Humite is only sporadically observed in subsolidus reactions; the equilibrium temperature for the reaction clinohumite+chondrodite $\rightleftharpoons$ humite could not be determined. Metastable crystallization of forsterite (in the place of chondrodite) occurs mostly on heating and fusion of norbergite.

In the ternary system MgO-MgF_2-SiO_2 some of the minerals of the humite-clinohumite series (on the join Mg_2SiO_4-MgF_2) could be outlined in their crystallization fields, with boundary curves to the fields of primary periclase, sellaite, cristobalite and/or tridymite, forsterite, and clinoenstatite. No Mg amphibole of the formula $Mg_7(Si_8O_{22})F_2$ was observed in the melt products.--Auth.

3-1886. Goldsmith, Julian R., and Hugh C. Heard. SUBSOLIDUS PHASE RELATIONS IN THE SYSTEM $CaCO_3$-$MgCO_3$: Jour. Geology, v. 69, no. 1, p. 45-74, 13 figs., 3 pls., 10 tables, Jan. 1961, 17 refs.

The solid solubility, disorder, and decomposition relationships in the system $CaCO_3$-$MgCO_3$ were investigated in the pressure range of from 10 to 10,000 bars and at temperatures of from 700° to 1,200°C. A sealed-tube technique was used for the most part in an internally heated pressure vessel designed for rapid operation.

The top of the solvus outlining the 2-phase field of magnesian calcites and dolomite is at a temperature of 1,075°C. at the composition $Ca_{57}Mg_{43}$, and above the solvus a single-phase region extends from $CaCO_3$ to $CaMg(CO_3)_2$. The solubility gap between $CaMg(CO_3)_2$ and $MgCO_3$ is considerably larger, and solubility of Ca^{++} in $MgCO_3$ and Mg^{++} in $CaMg(CO_3)_2$ is quite limited at 1,100°C. Cation disorder in stoichiometric dolomite becomes observable at approximately 1,000°C. and is complete at approximately 1,200°C., at which temperature $CaMg(CO_3)_2$ has the calcite-type structure. There is no evidence for anything but a continuous (higher-order) transformation over this 200°C. interval. Disorder is enhanced by substitution of Ca^{++} for Mg^{++} beyond the ideal 1:1 ratio in dolomite; the most Ca-rich dolomite showing any order exists at the top of the solvus. Thus a region exists in which, at temperatures above the solvus, disorder takes place at constant temperature along with the substitution of excess $CaCO_3$ into dolomite.

Both simple substitutional disorder and mixed-layer effects are observed in quenched samples near dolomite in composition. The relation of these high-temperature equilibrium states to the naturally occurring metastable low-temperature protodolomite-like materials is discussed. Consideration is also given to the relation between calcite I and calcite II in the system. Data on the $\underline{P}_{CO_2}$-$\underline{T}$ relations of $CaCO_3$, $MgCO_3$, and $CaMg(CO_3)_2$ are presented in an appendix.--Auth.

3-1887. Segnit, Ralph E., and George C. Kennedy. REACTIONS AND MELTING RELATIONS IN THE SYSTEM MUSCOVITE-QUARTZ AT HIGH PRESSURES: Am. Jour. Sci., v. 259, no. 4, p. 280-287, 3 figs., 3 tables, Apr. 1961, 6 refs.

The reaction of muscovite + quartz to sanidine + mullite has been examined as a function of temperature and H_2O pressure to 6 kb. Our results at low pressures are similar to those previously published by Yoder and Eugster. The muscovite = orthoclase + sillimanite isograd, commonly mapped by field petrologists, indicates temperatures in the range 650°-750°C. The reaction muscovite + quartz = muscovite + melt has been determined to 20 kb. The pressure coefficient of melting of a synthetic quaternary granite, where muscovite is the first crystalline phase to form, is approximately 6.5° per kilobar. Thus an ideal granite moving into shallower depths in the earth's crust from a depth of 30 km. can have no more than 16 calories per gram superheat.--Auth.

3-1888. Wahl, Floyd M., and others. PHASE TRANSFORMATIONS IN SILICA AS EXAMINED BY CONTINUOUS X-RAY DIFFRACTION: Am. Mineralogist, v. 46, no. 1/2, p. 196-208, 7 figs., table, Jan.-Feb. 1961, 17 refs.

The phase transformations of 6 different varieties of silica were examined by continuous X-ray diffraction while heated to 1400°C.

The (101) peak intensity changes which often accompany the α-β quartz inversion are a function of particle size. There is, however, no correlation between these changes and the gradual increase in the (101) $\underline{d}$-spacing as the material is heated.

The crystallization temperature of β-cristobalite from a siliceous material is a consequence of the crystallinity and initial structural perfection of that material - the better the crystallinity, the higher the transition temperature. Rock crystal quartz gives β-cristobalite at 1200°C.; whereas, amorphous silica gel produces this phase of 900°C.

Tridymite was not detected as a transitional phase mineral in the silica system.--Auth.

3-1889. Rao, C.N.R. KINETICS AND THERMODYNAMICS OF THE CRYSTAL STRUCTURE TRANSFORMATION OF SPECTROSCOPICALLY PURE ANATASE TO RUTILE: Can. Jour. Chemistry, v. 39, no. 3, p. 498-500, 2 figs., March 1961, 7 refs.

The transformation of spectroscopically pure anatase to rutile was first investigated by Czanderna, Rao, and Honig. But it was not possible, then, to provide the mechanism on a molecular scale because of the lack of very accurate kinetic data. The kinetics and thermodynamics of the transformation have now been carefully investigated.--Auth.

3-1890. Holser, William T., and C.J. Schneer. HYDROTHERMAL MAGNETITE: Geol. Soc. America, Bull., v. 72, no. 3, p. 369-385, 2 illus., 2 graphs, 3 tables, March 1961, 80 refs.

The solubility of magnetite was measured in dilute aqueous solutions of HCl at high temperature and pressure. At 390°C., 440 bars, in 0.0002 M HCl, 300 p.p.m. ferrous Fe is dissolved. Solubility decreases with acid concentration; in pure water at the same conditions solubility is less than 0.02 p.p.m. Calculation of real-gas equilibria from thermodynamic data shows that the contribution of volatile Fe_2Cl_6 molecules is insignificant in such dilute solutions. Comparison with room-temperature data suggests that ferrous Fe is brought into true solution mainly as Fe^{2+} ion, by reaction with H^+, although complexes such as $FeCl^{2+}$ and $FeOH^{2+}$ may participate.

Magnetite was synthesized by reaction of acidic iron chloride solutions with calcite at high temperature and pressure.

The amount of Fe measured in solutions with HCl concentrations less than a hundredth of that of natural fluids is great enough to be geologically significant.--Auth.

3-1891. Mason, Brian, and H.B. Wiik. THE HOLBROOK, ARIZONA, CHONDRITE: Geochim. et Cosmochim. Acta, v. 21, no. 3/4, p. 276-283, 4 tables,

Jan. 1961, 34 refs.

The Holbrook chondrite has been reanalyzed, with the following results: Fe 7.18, Ni 1.09, Co 0.054, Cu 0.0096, FeS 7.94, SiO_2 40.11, TiO_2 0.14, Al_2O_3 1.90, Cr_2O_3 0.51, FeO 12.01, MnO 0.37, MgO 25.18, CaO 1.74, Na_2O 0.93, K_2O 0.10, P_2O_5 0.40, H_2O 0.27, C 0.06; total 99.99. The mineralogical composition is olivine (Fo_{74}), hypersthene (En_{76}), plagioclase (An_{15}), Ni-Fe, troilite, chromite, and possibly apatite. The density of the meteorite is 3.56. A summary of the data on the abundances of Ba, Bi, Cs, Cu, In, Pb, Li, Hg, Rb, Sc, Se, Sr, Te, Tl, Th, U, V, Y, and Zr in this meteorite is included.--Auth.

3-1892. Mason, Brian, and H. B. Wiik. THE MILLER, ARKANSAS, CHONDRITE: Geochim. et Cosmochim. Acta, v. 21, no. 3/4, p. 266-271, 3 illus., 2 tables, Jan. 1961, 11 refs.

The Miller chondrite has been analyzed, with the following results: Fe 19.90, Ni 1.60, Co 0.061, FeS 5.39, SiO_2 38.13, TiO_2 0.142, Al_2O_3 2.06, Cr_2O_3 0.32, FeO 4.74, MnO 0.31, MgO 23.71, CaO 1.61, Na_2O 0.82, K_2O 0.098, P_2O_5 0.50, H_2O+ 0.06, C 0.015. The mineralogical composition is orthopyroxene (En_{82}), olivine (Fo_{82}), plagioclase (An_{10}), Ni-Fe, troilite, chromite, traces of diopside, and probably a little apatite; a single grain of native Cu was seen on a polished surface of the meteorite. The density of the meteorite is 3.68.--Auth.

3-1893. Mason, Brian, and H. B. Wiik. THE KYUSHU, JAPAN, CHONDRITE: Geochim. et Cosmochim. Acta, v. 21, no. 3/4, p. 272-275, 2 tables, Jan. 1961, 12 refs.

The Kyushu chondrite has been analyzed, with the following results: Fe 6.27, Ni 1.34, Co 0.046, FeS 5.89, SiO_2 39.93, TiO_2 0.14, Al_2O_3 1.86, Cr_2O_3 0.54, FeO 15.44, MnO 0.33, MgO 24.71, CaO 1.70, NaO 0.74, K_2O 0.13, P_2O_5 0.31, H_2O+ 0.27, C 0.03; total 99.67. The mineralogical composition is olivine (Fo_{74}), hypersthene (En_{78}), maskelynite, Ni-Fe, troilite, chromite, and possibly apatite. The density of the meteorite is 3.53.--Auth.

3-1894. Vorobev, G. G. THE RIDDLE OF TEKTITES. Translated by A. J. Schneiderov: Internat. Geology Rev., v. 3, no. 3, p. 227-229, 2 illus., map, March 1961.

Since their discovery in Czechoslovakia in the 17th century, tektites have been found on all 5 populated continents. The largest Czech tektites weigh about 100 g. More than 11 kg. of samples have been collected from Australia alone. Three principal sources have been postulated: meteoric, lunar, and terrestrial. No theory has yet been generally accepted.--M. Russell.

3-1895. Kaye, Clifford A., and others. TEKTITE FROM MARTHA'S VINEYARD, MASSACHUSETTS: Geol. Soc. America, Bull., v. 72, no. 2, p. 339-340, 4 illus., table, Feb. 1961, 3 refs.

A fragment of an oddly sculptured glass disc found on the cliff of Gay Head, on Martha's Vineyard, Massachusetts, is thought to be a tektite. Unless carried to Gay Head by man from one of the known tektite fields, it raises to 3 the number of tektite localities in the Western Hemisphere. The freshness of surface features and the clarity of glass indicate a recent origin. If, however, it weathered out of the cliff, it may be Late Cretaceous, Miocene, or Pleistocene in age.--Auth.

3-1896. Feller-Kniepmeier, M., and Herbert H. Uhlig. NICKEL ANALYSES OF METALLIC METEORITES BY THE ELECTRON-PROBE MICROANALYSER: Geochim. et Cosmochim. Acta, v. 21, no. 3/4, p. 257-265, 20 figs., 2 tables, Jan. 1961, 24 refs.

The electron-probe microanalyzer was used to obtain Ni analyses of separate phases in 9 metallic and 1 stony meteorite. Proper surface preparation and adequate calibration were found to be important. Kamacite composition was uniform throughout the phase. In swathing kamacite, however, Ni became appreciably lower near a schreibersite inclusion. Taenite exhibited a marked composition gradient which increased at the taenite-kamacite interface. The Ni content of fine plessite was intermediate. It also exhibited a Ni concentration gradient, which was continuous with that of adjacent taenite. These facts accord with cooling of the original meteorite body or bodies over a long period of time to a temperature of 300°C. or lower. The time was short of that required to produce uniform composition taenite, or uniform composition kamacite near schreibersite inclusions.--Auth.

3-1897. Turekian, Karl K., and Karl Hans Wedepohl. DISTRIBUTION OF THE ELEMENTS IN SOME MAJOR UNITS OF THE EARTH'S CRUST: Geol. Soc. America, Bull., v. 72, no. 2, p. 175-191, 2 tables, Feb. 1961, 138 refs.

This paper presents a table of abundances of the elements in the various major units of the Earth's lithic crust, with a documentation of the sources and a discussion of the choice of units and data.--Auth.

3-1898. Halva, Carroll. A SEMI-MICRO ANALYSIS OF SILICATE ROCKS FOR Ca, Mg, Fe, AND Al EMPLOYING E. D. T. A.: Arizona Geol. Soc., Digest, v. 3, p. 81-86, 4 tables, 1960, 14 refs.

A rapid, accurate analysis of total Fe, Al, Ca, and Mg in silicate rocks using EDTA as the analytical agent has been developed using semi-micro techniques. It gives approximately 80% of the composition of the average igneous rock other than SiO_2. A single analysis takes 3 hours, but, if done in quantity, as many as 8 determinations can be made in an 8-hour day. The method is described, including a section on the preparation of the sample, analysis of the sample solution, and results of the analysis of various known rocks.--M. Russell.

3-1899. Hahn-Weinheimer, P., and F. Rost. AKZESSORISCHE MINERALIEN UND ELEMENTE IM SERPENTINIT VON LEUPOLDSGRÜN (MÜNCHBERGER GNEISMASSE). EIN BEITRAG ZUR GEOCHEMIE ULTRABASISCHER GESTEINE [Accessory Minerals and Elements in the Serpentinite of Leupoldsgrün (Münchberger Gneismasse). A Contribution to the Geochemistry of Ultrabasic Rocks]: Geochim. et Cosmochim. Acta, v. 21, no. 3/4, p. 165-181, 6 figs., 9 tables, Jan. 1961, 27 refs.; text in German, abs. in English.

With the antigoritization of serpentinite near Leupoldsgrün, Oberfranken (West Germany), caused by stress, brucite was formed intermediately. Together with magnetite, the fine-grained brucite filled numerous small joints along schistosity. The formation of brucite was followed by antigoritization and other changes in serpentinite. Simultaneously with changes in the silicate phases, several phases of ore, especially magnetite, were formed.

Chemical and spectrochemical research on composition and accessory elements shows that the serpentinite of Leupoldsgrün as well as others of the "Münchberger Gneismasse" belong to the magmatic group of ultrabasic rocks. Average contents in serpentinites of Leupoldsgrün have been determined: Ni 0.243%, Co 0.017%, Cr 0.274%. Also Pd and Pt show remarkably high values up to 0.83 p.p.m. Pd and 0.22 p.p.m. Pt.

In connection with the geochemistry of Ni the ore mineral "Awaruit" (Ni, Fe) has been found, described and its genesis discussed.--Auth.

3-1900. Fanale, Fraser, and J. Laurence Kulp. HELIUM IN LIMESTONE AND MARBLE: Am. Mineralogist, v. 46, no. 1/2, p. 155-167, 4 tables, Jan.-Feb. 1961, 13 refs.

The He and U content of a number of specimens of marble, Iceland spar, and fossil shell of known age have been determined. The sedimentary calcite specimens contained only a small fraction of the He expected, indicating that most of the U is external to the lattice. The marbles in contrast contain much more He than is calculated from the age and the alpha activity. This appears related to the gaseous inclusions in these materials.--Auth.

3-1901. Harder, H. EINBAU VON BOR IN DETRITISCHE TONMINERALE. EXPERIMENTE ZUR ERKLÄRUNG DES BORGEHALTES TONIGER SEDIMENTS [Incorporation of Boron in Detrital Clay Minerals. Experiments on the Explanation of Boron Content of Clay Sediments]: Geochim. et Cosmochim. Acta, v. 21, no. 3/4, p. 284-294, tables, Jan. 1961, 14 refs.; text in German, abs. in English.

Geochemical research had shown that the high concentrations of B of clay sediments are attributable to the illites. These contents of B are either due to later absorption from the sea water or to new formation of micas with simultaneous installation of B.

Having treated clays poor of B with solvents containing B, it could be shown by experiment that clays can take B from the solvents. The absorbed quantities of B depend on the duration of treatment, on temperature, on concentration of B, on pH of the solvents, and on the mineralogical composition of the investigated clays. Dioctahedral micas absorb more B than the further clay minerals as kaolinite, montmorillonite and others.

Since B practically cannot be washed away and since there is no adjustment of chemical equilibrium even after a longer treatment, adsorption cannot exist, and it is to suppose that an installation of cations of B into the lattice of mica takes place. It is probable that B replaces the Al resp. the Si in the tetrahedral position.

Through these experiments it is likely that illites mostly are concerned as relics of weathering and to a less degree as new formations.--Auth.

3-1902. Swain, Frederick M. LIMNOLOGY AND AMINO-ACID CONTENT OF SOME LAKE DEPOSITS IN MINNESOTA, MONTANA, NEVADA, AND LOUISIANA: Geol. Soc. America, Bull., v. 72, no. 4, p. 519-545, 13 figs., 4 pls., 4 tables, Apr. 1961, 27 refs.

Sedimentary features and amino-acid content are described for several lakes in the Anoka sand plain, east-central Minnesota; other lakes in Minnesota; Flathead Lake, Montana; Pyramid Lake, Nevada; and Catahoula Lake, Louisiana.

The limnology of the Anoka Sand Plain lakes is related to the characteristics of the "gray" sandy calcareous Mankato drift of the Des Moines lobe which underlies much of the sand plain; the "red," less calcareous, Superior lobe drift which forms the eastern border of, and patches within, the sand plain has less effect on the lakes.

The scarcity of varved Recent lake deposits in Minnesota is believed to result in large part from the reworking activity of benthonic organisms. As a result, measurements of some properties of the mixed bottom materials have little chronologic significance.

Free amino acids are rare or absent in the lake sediments, but amino acids ranging from less than 2 p.p.m. to more than 4,000 p.p.m. on a wet-weight basis were obtained in acid hydrolysates of the sediments. The amino acids probably occur as glutelin or scleroprotein types of proteins, as peptides, or tied to humic-acid substances in these sediments.

Neutral peat deposits and well-humified organic lake deposits yield neutral and acidic amino acids in approximate proportions of 6:1; alkaline bogs and well-humified organic marls yield neutral and acidic amino acids in proportions of about 3:1; acid peats contain basic amino acids in addition to neutral and acidic types. Incompletely humified lake deposits yield variable proportions of all 3 types of amino acids. To the extent that the amino acids were involved in microbiological transformations in the accumulating deposits, the observed proportions of the amino acids are believed to be related to their Zwitter ion properties.

Lake sediments of low organic content generally yield small amounts of neutral amino acids but typically lack acidic or basic amino acids.--Auth.

3-1903. Umemoto, Shunji. AN EXAMPLE OF VARIATION IN CONSTITUENTS OF HOT SPRINGS: Geochim. et Cosmochim. Acta, v. 21, no. 3/4, p. 239-246, 5 figs., 4 tables, Jan. 1961, 7 refs.

A consideration of the observed results obtained at Misasa Hot Springs, Japan, has led to the following conclusions: when a factor acts continuously on the hot spring, the frequency distribution of the observed values for each constituent is normal, but the combined effect of several factors may cause the frequency distributions to be non-normal. Then, the extent of the effect caused by a given factor might be determined by the test for non-normality of the frequency distribution of observed values with respect to that factor.--Auth.

3-1904. Lewin, Joyce C. THE DISSOLUTION OF SILICA FROM DIATOM WALLS: Geochim. et Cosmochim. Acta, v. 21, no. 3/4, p. 182-198, 25 figs., Jan. 1961, 47 refs.

Silica walls of diatoms, prepared by digesting cultured cells with nitric acid, dissolved more rapidly in media of higher pH or at higher temperatures. Most of the studies reported here were carried out in Tris buffer at pH 9.0-9.3 and at 19°C. The rate of dissolution under these conditions was slightly less than in sea water at pH 8.0, since NaCl accelerates the dissolution of silica. The silica from cleaned diatom walls dissolved in Tris buffer until, after 3-4 weeks, the solution had become saturated at 40-50 mg. Si/1. (85-110 mg.SiO_2/1.). The rate of solution decreased with time, probably due to the presence of silica in different states of hydration. Living cells suspended in buffer in darkness remained viable for many weeks during which time very little Si dissolved from their walls. However, every treatment which killed the cells (heat, protein-denaturing agents, organic solvents, breakage) resulted in an increase in the rate of silica dissolution, although this rate was never as great as from acid-cleaned walls.

Experiments with EDTA indicated that a cationic inorganic factor was retarding silica dissolution from killed cells. Pretreatment of cleaned silica walls with salts of Al, Be, Fe, Ga, Gd, Sc, Ti, Y, and Yb at pH values between 2.0 and 9.0, and with Mn at pH values between 4.0 and 11.0, had various effects on the subsequent rate of dissolution of the silica at pH 9.0. At certain pH values each of these elements can evidently combine superficially with amorphous silica and thereby retard its rate of dissolution. Pretreatment of cleaned silica walls with salts of La, Mo, Cr, at pH values between 2.0 and 9.0, and with Ca and Mg at pH values between 4.0 and 11.0, had no effect on their subsequent dissolution at pH 9.0. Al, Be, Fe, Ga, Gd, and Y were all capable of combining with silica walls at pH 8.0, which is the pH of sea water, and thereby retarding their subsequent dissolution. A single determination showed that the walls adsorbed Al equivalent to 1% of their weight. In retarding dissolution of the silica, Al was as effective on killed, but intact, cells as on acid-cleaned walls.

The silica of 9 samples of untreated diatomaceous earth of fresh-water and marine origins, ranging in age from Upper Cretaceous through Pliocene, was essentially insoluble under these conditions. Digestion in strong nitric acid freed only a small fraction of the silica for dissolution. The factor which retarded the initial dissolution of silica from natural marine phytoplankton could be removed completely by pretreating the cells with a chelation mixture of EDTA and oxalate. DHEG, which is reported to complex certain cations such as Fe, but to have no effect on Ca or Mg, was equally effective.

It can be concluded that certain adsorbed inorganic cations decrease the rate of dissolution of diatomaceous silica. In living diatom cells there may be an additional mechanism for stabilizing silica walls. --Auth.

3-1905. Kokubu, Nobuhide, and others. DEUTERIUM CONTENT OF MINERALS, ROCKS AND LIQUID INCLUSION FROM ROCKS: Geochim. et Cosmochim. Acta, v. 21, no. 3/4, p. 247-256, 2 figs., 3 tables, Jan. 1961, 18 refs.

Samples of some minerals, rocks, and liquid inclusions from rocks have been analyzed for water and deuterium content of the water. Samples from Hawaii and Japan were selected with the prime objective of securing juvenile water. It is found that the water of these samples contains less deuterium than the average surface water of the earth, and it is concluded that juvenile water does not contain as much deuterium as the oceans. Possible explanations for the discrepancy are offered. 1) Protium equivalent to about 4% of the oceans has escaped from the earth with a negligible loss of deuterium. 2) The earth at its formation acquired surface water of high deuterium content and deeply buried water of low deuterium content. It is pointed out that certain carbonaceous chondrites contain the highest concentrations of deuterium ever found in nature, while others of this group contain water of about average terrestrial composition. Other samples of water have been analyzed and are reported even though the results do not contribute to the main problem. The results do not differ in any important way from others reported in the literature. --Auth.

3-1906. Brown, R. M. HYDROLOGY OF TRITIUM IN THE OTTAWA VALLEY: Geochim. et Cosmochim. Acta, v. 21, no. 3/4, p. 199-215, 5 figs., 5 tables, Jan. 1961, 18 refs.

Tritium deposition in rain water at Ottawa, Canada, is reported for the years 1953-1959. Correlation with the tritium content of drainage water in the district has allowed study of the hydrodynamics of the water system. A turnover rate constant of 0.27 year^{-1} has been found for a storage reservoir of 2.1 m. The fraction of fresh precipitation in re-evaporated water has been estimated as 0.55 ± 0.1. A deposition rate of cosmic tritium of 1.3 ± 0.1 atoms/cm.^{2} sec. has been obtained from early data. --Auth.

3-1907. Shur, A. S. ARGON METHOD OF DETERMINING THE ABSOLUTE AGE OF ROCKS AND MINERALS: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 6, p. 95-97, diag., pub. 1961.

There are, at present, 2 experimental methods of determining the absolute age of rocks and minerals, the mass-spectrometric and the volumetric methods. To speed up the necessary operations in the volumetric method, the author describes a special installation which permits 6 experiments at the same time. The tested crushed sample is placed into a quartz ampoule into which is introduced a heating spiral. The Mo glass reactor is closed by a slide in the stopper to which 2 electric Mo wires are soldered. Temperature regulation is made by an autotransformer. Temperature is measured by a thermocouple. Measurement of radiogenic Ar is made separately with a McLeod gage. --From LC.

3-1908. Rose, Harry, Jr., and Thomas W. Stern. SPECTROCHEMICAL DETERMINATION OF LEAD IN ZIRCON FOR LEAD-ALPHA AGE MEASUREMENTS: Am. Mineralogist, v. 45, no. 11/12, p. 1243-1256, 2 figs., 3 tables, Nov.-Dec. 1960, 7 refs.

A spectrochemical method is described for determining Pb in zircon. A synthetic "zircon" standard is used to cover a range of concentration between 1 and 560 p.p.m. The method is designed for use in Pb-alpha age measurements. Results of the analysis of 22 zircons indicate an over-all 5% average deviation from isotope dilution and chemical values. This method differs from a spectrochemical method described previously in the composition of the standards and in the use of a full set of standards in preference to bracketing the samples. --Auth.

3-1909. Damon, Paul E., and others. RADIOMETRIC DETERMINATION OF POTASSIUM IN SILICATES: Arizona Geol. Soc., Digest, v. 3, p. 75-80, 2 tables, 1960, 13 refs.

The alpha-beta radiometric method for K analysis, requiring no chemical preparation, is discussed. It involves the alpha and beta counting of a powdered sample. The beta count may be taken with or without a 5-mil Al absorber to eliminate the soft beta particles from Rb-87. The beta count is then reduced by an empirical correction for the betas resulting from the U and Th series. The alpha count, which is due only to the U and Th series, determines the magnitude of this correction. The resulting beta count is compared with a standard sample of K to determine the K content.--M. Russell.

3-1910. Libby, W. F. RADIOCARBON DATING: Science, v. 133, no. 3453, p. 621-629, 9 illus., diag., 2 graphs, 2 tables, March 3, 1961, 2 refs.

A review of the origins, techniques, accuracy, and applications of radiocarbon age datings. Specific application to geology includes a discussion of the dating of the last ice age.--F. P. Glasser.

8. MINERALOGY AND CRYSTALLOGRAPHY

See also: Igneous and Metamorphic Petrology 3-1972; Sedimentary Petrology 3-1976, 3-1994.

3-1911. Ball, H. W. MINERALS AND ROCKS. Photographs by Scaioni: 96 p., 94 illus. (part col.), Garden City, New York, Hanover House, 1959.

Essentially a volume of photographs, both color and black-and-white, prepared to emphasize the aesthetic qualities of minerals, most of them so-called "common" minerals, and rocks. It tries to show that even the most humble members of the mineral kingdom may have in their natural state and intrinsic beauty surpassing that of the more familiar and flamboyant gemstones, which require cutting and polishing to give of their best. Although the photographs are the core of the book, it is the aim of the text to present the orderliness of the mineral kingdom and to show how man's increasing awareness of this has been translated into the sciences of mineralogy and petrology.--From introd.

3-1912. Kelly, William C., and John M. DeNoyer. A HEATING MICRO-COIL FOR THE STUDY OF MINERAL FRAGMENTS AND HEAT-ETCHING OF POLISHED SECTIONS: Am. Mineralogist, v. 45, no. 11/12, p. 1185-1197, 5 figs., 2 tables, Nov.-Dec. 1960, 9 refs.

A small heating coil is described that can be used to heat selected mineral grains in a microscopic field of view to partially controlled temperatures as high as 400°C. Preliminary tests have been made on mineral fragments and minerals in polished section. Samples can be watched as they are heated. A wide variety of effects such as color changes, release of sublimates, dehydration, melting, and the cracking and explosion of grains have been observed in testing mineral fragments. Many of the more heat sensitive ore minerals studied in polished section showed unusual reactions to the heat of the coil. The copper sulfides and some Ag minerals proved to be most reactive. Heat-etching of chalcocite produced the distinctive patterns previously described by Stephens.--Auth.

3-1913. Robertson, Forbes. KNOOP HARDNESS NUMBERS FOR 127 OPAQUE MINERALS: Geol. Soc. America, Bull., v. 72, no. 4, p. 621-637, 5 tables, Apr. 1961, 9 refs.

Knoop identation hardness numbers may be obtained on polished mineral grains as small as 10 microns in diameter. This paper gives average Knoop numbers for 127 opaque minerals and quartz. The limits of tests and the average hardness number are plotted on a logarithmic scale on which the lines representing the hardness range for a given mineral are reasonably comparable throughout the range from 1 to 1,500.

Bismuth (0.7) is the softest mineral tested, berthierite (1,140) the hardest. Other representative hardnesses (Talmage-scale equivalents in parentheses) are: argentite, 26 (A); galena, 75 (B); chalcopyrite, 175 (C); tetrahedrite, 299 (D); niccolite, 460 (E); magnetite, 528 (F); ilmenite, 965 (G). Quartz, 467 (7 on the Mohs scale), is approximately equivalent on the Knoop scale to niccolite, 460 (5-5 1/2 on the Mohs scale), and goethite, 476 (5-5 1/2 on the Mohs scale), and softer than magnetite, 536 (5 1/2-6 1/2 on the Mohs scale).

Some minerals exhibit striking differences in hardness in different crystallographic orientations. Molybdenite has a hardness of 12 parallel to {0001} cleavage and 60 at right angles to the cleavage; huebnerite is 313 parallel to {010} cleavage and 463 at right angles to cleavage; enargite is 154 parallel to {110} cleavage and 378 at right angles to cleavage. --Auth.

3-1914. Wolff, G. A., and J. D. Broder. CLEAVAGE AND THE IDENTIFICATION OF MINERALS: Am. Mineralogist, v. 45, no. 11/12, p. 1230-1242, 3 figs., table, Nov.-Dec. 1960, 10 refs.

"Mechanical etching" of substances gives a characteristic pattern that can serve as a means of identifying unknown minerals and other crystalline materials. The surfaces of single crystals can be ground with coarse abrasives in several ways; the microcleavage pits obtained can then be investigated by the light figure method. Sharp and diffuse spots and zonal reflections make up the pattern observed. The spots correspond to plane cleavages (macrocleavage) and the zones correspond to cylindrically curved microcleavages. There is always a center of symmetry introduced into the pattern, because in cleavage and microcleavage, the two newly created surfaces match.

Minerals and synthesized materials of various kinds have been investigated, and their patterns recorded. These patterns are arranged according to their structural relationship; similar patterns have been found for members of identical structure groups. Charts of these patterns, when arranged according to crystal systems and structures, will aid in the identification of unknown crystalline materials. Among the groups investigated were pyrite, marcasite, sphalerite, wurtzite, barite, halite, chrysolite, and other structure groups.--Auth.

3-1915. Bloss, F. Donald, and Gerald V. Gibbs. NOMOGRAMS FOR DETERMINING 2θ FROM PRECESSION PHOTOGRAPHS: Am. Mineralogist, v. 46, no. 1/2, p. 26-31, 3 figs., table, Jan.-Feb. 1961.

Two nomograms are presented which permit 2θ to be evaluated from diffraction spot locations on precession photographs. By means of the first nomogram, 2θ for the wavelength used to produce the precession photograph is obtained. The second permits 2θ ($CuK\alpha$) to be determined from precession spots produced by Mo ($K\alpha$) radiation. The accuracy is usually sufficient to allow, in conjunction with observed intensities, unequivocal indexing of the more intense powder diffraction lines of crystalline materials.--Auth.

3-1916. Wolfe, C. Wroe. CRYSTAL SYNTHESIS BY REFRIGERATION: Am. Mineralogist, v. 45, no. 11/12, p. 1211-1220, fig., Nov.-Dec. 1960, ref.

Maser operation requires crystals containing paramagnetic ions such as Cr or Ni in minute percentages which substitute generally for Co, Al, or Mg. Crystals of $K_3(Co_{0.995}Cr_{0.005})(CN)_6$ have been grown in freezer compartments at temperatures of 4° to 5°C. Seeds for crystals are inserted in solutions which are saturated at ~0°C. in the freezer. Controlled quantities of solutions which are saturated at room temperature are periodically introduced into the freezer solution. The desired effect is that the growing crystals will adsorb all precipitating ions above the saturation level to eliminate additional spontaneous seeding. Daily turning of the crystals is conducive to homogeneous growth. Growth rates have been measured. Small crystals have a faster growth rate per unit weight but a lesser mass accumulation per unit time than larger crystals. Space restrictions are the only limitations on the maximum size that can be developed. Single crystals as large as: $\underline{c} = 12$ cm., $\underline{b} = 4$ cm., $\underline{a} = 3$ cm. have been prepared during a 3-month growing period.--Auth.

3-1917. Belov, N.V. THE CRYSTAL STRUCTURE OF BADDELEYITE (MONOCLINIC ZrO_2): Kristallografiya [in translation], v. 5, no. 3, p. 436-438, 3 figs., Nov.-Dec. 1960, 8 refs.

Baddeleyite, the low temperature monoclinic modification of ZrO_2, has a structure which is a distortion of the high temperature cubic (fluorite structure type) modification. The coordination number of Zr is 7, rather than 8 as in the high temperature form. The unit cell contains 2 alternating layers of O ions and cations. One of the O layers is slightly distorted from the higher temperature cubic arrangement, whereas the second is considerably distorted as well as transformed to a tetragonal motif, consisting of a square net alternating with twice the number of triangular nets. The location of the Zr atoms between these distorted layers is such as to place them within an O polyhedron of 2 different kinds of bases - one almost square and the other triangular.--E.G. Ehlers.

3-1918. Venevtsev, Yu.N., and others. CRYSTAL CHEMICAL STUDIES OF SUBSTANCES WITH PEROVSKITE TYPE STRUCTURE AND SPECIAL DIELECTRIC PROPERTIES: Kristallografiya [in translation], v. 5, no. 4, p. 594-599, Jan.-Feb. 1961, 29 refs.

Anomalous changes have been found in the lattice parameters and dielectric and piezoelectric properties of $(Ba, Pb)TiO_3$ solid solutions. Some of these anomalies are due to the different ions responsible for the ferroelectric activity of $BaTiO_3$ and $PbTiO_3$ (B ion = Ti and A ion = Pb). Some of the discrepancies between X-ray and optical data on the symmetry of the high-temperature phases of $NaNbO_3$ have been removed by the use of the X-ray method. The $BaTiO_3$-type solid solutions obtained as the result of simultaneous substitution of Ba and Ti ions by A' and B' ions respectively (where A' = Ca, Sr, Bi and B' = Sn, Zr, Al, Cr) have been studied. The data obtained together with known data on solid solutions, in which Ba and Ti ions replaced by A' = Ba, Sr, Ca and B' = Ti, Sn, Zr ions permits analysis of the influence of different factors on the Curie temperature.

It has been shown that the dielectric properties of some ferro- and antiferroelectric materials can be substantially improved by varying their composition.

A general method for calculating the internal fields has been developed for the crystal structures of any possible dipole configurations. The method has been applied to the real orthorhombic structure of $CaTiO_3$. In this case, the internal electric field at the Ti sites is equal to zero in contrast to the case of ABO_3-type ferroelectric materials.--Auth.

3-1919. Evans, Howard T., Jr., and Mary E. Mrose. A CRYSTAL CHEMICAL STUDY OF THE VANADIUM OXIDE MINERALS, HÄGGITE AND DOLORESITE: Am. Mineralogist, v. 45, no. 11/12, p. 1144-1166, 13 figs., 5 tables, Nov.-Dec. 1960, 11 refs.

Small, black vanadium oxide crystals obtained from a sandstone drill core taken near Carlile, Wyoming, were found by single-crystal X-ray diffraction techniques to consist of 2 monoclinic phases. Crystal structure analysis showed one phase to be a new mineral, häggite, having the following crystallographic properties: space group $C2/m$; cell dimensions, $\underline{a} = 12.17$ Å, $\underline{b} = 2.99$, $\underline{c} = 4.83$, $\beta = 98°15'$; cell contents, $H_6V_4O_{12}$. The second phase ("phase B") was found to have crystallographic properties identical with those of the previously described doloresite: space group, $C2/m$; cell dimensions, $\underline{a} = 19.64$ Å, $\underline{b} = 2.99$, $\underline{c} = 4.83$, $\beta = 103°55'$; cell contents, $H_8V_6O_{16}$ or $H_{10}V_6O_{16}$. The presence of the H atoms was established by recognizing H bonds from O-O distances and V-O bond distributions. To obtain the best interatomic distance data, the structures of both phases were refined by least squares analysis.

Häggite, phase B, and duttonite (H_2VO_3) are considered to be members of a homologous series of general composition $H_{2n-2}V_nO_{3n-2}$, with $\underline{n} = 4$, 6, and ∞, respectively.

The problem of the chemical nature of doloresite was solved with information obtained from a study of the Carlile crystals. Doloresite is invariably twinned on (100) on a submicroscopic scale, producing pseudo-orthorhombic X-ray patterns. The X-ray intensities of the twin composite reflections are well accounted for in terms of the crystal structure found for phase B. Phase B is not twinned, but is intergrown with häggite in parallel orientation ($\underline{b}$ and $\underline{c}$ axes coincident) on a submicroscopic scale. The structural relationships and modes of occurrence of these minerals lead to the hypothetical conclusion that doloresite ($H_8V_6O_{16}$) is metastable and is formed by solid state oxidation of phase B ($H_{10}V_6O_{16}$), which is formed by metasomatic replacement of montroseite. The häggite and phase B from Carlile appear to have been directly crystallized from the primary mineralizing solutions. The mechanisms whereby these processes may have taken place are described.--Auth.

3-1920. Bengus, V.Z., and others. DEVELOPMENT OF DISLOCATIONS IN CALCITE CRYSTALS: Kristallografiya [in translation], v. 5, no. 3, p. 418-422, 9 illus., Nov.-Dec. 1960, 17 refs.

Selective etchings of calcite were made using a 10% aqueous solution of tartaric acid. The etching time was 10-30 sec., followed by washing in distilled water and in ethyl alchol and drying in air. Etch pits on cleavage planes correspond in location to dislocation lines. Dislocations are concentrated at the boundaries between the crystal and its twin layers. Etch bands of a dislocational nature were observed. --E.G. Ehlers.

3-1921. Frank-Kamenetsky, V.A. MANIFESTATION OF MICROISOMORPHISM IN QUARTZ: Kristallografiya [in translation], v. 5, no. 4, p. 622-626, 4 figs., Jan.-Feb. 1961, 13 refs.

Precision X-ray data are presented for 10 natural and 35 synthetic quartz crystals differing in origin and composition. The lattice parameter variations are: a = 4.9026 – 4.9038, c = 5.3933 – 5.3945 kX (synthetic); a = 4.9023 – 4.9039, c = 5.3923 – 5.3944 kX (natural).

Lattice parameters are compared with impurity contents. It is shown that impurities such as Al, Na, Fe, Mg, and Ge cause microisomorphous substitution in the quartz lattice. The unit cell becomes larger with increasing impurity content. Microisomorphous relations act on the growth and morphology of quartz and are also connected with the genetic and paragenetic conditions of natural quartz.--Auth.

3-1922. Stubičan V., and Rustum Roy. ISOMORPHOUS SUBSTITUTION AND INFRA-RED SPECTRA OF THE LAYER LATTICE SILICATES: Am. Mineralogist, v. 46, no. 1/2, p. 32-51, 21 figs., table, Jan.-Feb. 1961, 25 refs.

Infrared spectra of series of dioctahedral and trioctahedral synthetic clays in the region 400-5,000 cm.$^{-1}$ have been obtained. Characteristic changes in the IR spectra with ionic substitution have been observed with both types. From these results some general conclusions concerning the variations of IR spectra with ionic substitution in both groups of clay minerals can be drawn. In many cases quantitative relationships between frequencies or intensities of the characteristic absorption bands and the extent of ionic substitutions could be established. The same parameters can also be used for the location of substituent ions.--Auth.

3-1923. Simonov, V.I. BAOTITE - A MINERAL WITH [Si_4O_{12}] METASILICATE RINGS: Kristallografiya [in translation], v. 5, no. 4, p. 523-525, fig., table, Jan.-Feb. 1961, 7 refs.

The crystal structure of baotite (space group $I4_1/a$, dimensions of the unit cell: a = 19.68, c = 5.88 A) has been established by the method of minimalization of Patterson projections. The final atomic coordinates resulted from several computings of signs of hkl alternating with Fourier syntheses. Baotite is a new example of a ring silicate with a tetragonal radical [Si_4O_{12}]. The detailed formula of baotite is $Ba_4(Ti, Nb)_8ClO_{16}[Si_4O_{12}]$. The ring radicals [$Si_4O_{12}$] are on the 4-fold inversion axes, and (Ti, Nb)-octahedra are around 4-fold screw axes in columns analogous to those in the structure of rutile.--Auth.

3-1924. Pyatenko, Yu.A., and Z.V. Pudovkina. CRYSTAL STRUCTURE OF NARSARSUKITE: Kristallografiya [in translation], v. 5, no. 4, p. 540-548, 7 figs., 5 tables, Jan.-Feb. 1961, 4 refs.

The complete crystal structure investigation of narsarsukite $Na_2(Ti, Fe)(O, OH)$-[Si_4O_{10}] has been undertaken. It was found that narsarsukite is tetragonal, the unit cell dimensions being a = 10.72, c = 7.99 Å. Atomic arrangement was determined by Patterson and Fourier syntheses. Narsarsukite represents a new structure type with [Si_4O_{10}] ∞ chains stretching along $\underline{c}$.--Auth.

3-1925. Sclar, Charles B. OPTICAL CRYSTALLOGRAPHY OF ORIENTITE FROM ORIENTE PROVINCE, CUBA: Am. Mineralogist, v. 46, no. 1/2, p. 226-232, 3 tables, Jan.-Feb. 1961, 16 refs.

The optic orientation, optic angle, optic sign, and pleochroic formula of orientite [$Ca_4Mn_4^{+3}(SiO_4)_5 \cdot 4H_2O$] recorded in the literature are incorrect, and a revision of the optical crystallography of orientite is presented.

Orientite is orthorhombic,

$$\frac{2}{m}\frac{2}{m}\frac{2}{m},$$

dominant forms {110}, {001}, and {010}, prismatic to tabular parallel to {010}, (110) ∧ ($1\bar{1}0$) = 67°48', $\underline{a}:\underline{b}:\underline{c}$ 0.6720:1:0.3958, imperfect basal {001} and brachyprismatic {120} cleavage, sp. gr. = 3.05. The Barker classification angles are $\underline{cr}$ = 30°30', $\underline{am}$ = 33° 54', and $\underline{bq}$ = 68°24'.

The optic orientation of orientite is X = $\underline{b}$, Y = $\underline{c}$, Z = a with α=1.756, β=1.777, γ=1.794 (all ± 0.002). The optic plane is transverse to the elongation, and the optic angle is large, negative, and variable ($2V_x$ = 68-83°). It has very strong dispersion ($\underline{r} < \underline{v}$) of the optic axes which are essentially normal to the brachyprismatic {120} cleavage. Orientite is deep red brown in color and strongly pleochroic in section with X = yellow, Y = yellow-brown, Z = red-brown, and Z > Y > X.

X-ray powder diffraction data for orientite are given for reference.--Auth.

3-1926. Zvyagin, B. B., and K. S. Mishchenko. ELECTRON-DIFFRACTION REFINEMENT OF THE STRUCTURE OF MUSCOVITE: Kristallografiya [in translation], v. 5, no. 4, p. 575-579, 3 figs., 3 tables, Jan.-Feb. 1961, 10 refs.

On the basis of electron-diffraction data from texture patterns a refinement of the structure of muscovite has been carried out with the use of Fourier syntheses. It has been established that Al may replace Si only in the half of the tetrahedra which are joined to the oxygens next to the glide planes of the octahedral layer. The substitution of Al in a tetrahedron results mainly in a change in the O position in the reflection plane of the tetrahedral layer, and, as a result, in a shift of K, and this leads to a slight increase in β over the theoretical value.--Auth.

3-1927. Wada, Koji. LATTICE EXPANSION OF KAOLIN MINERALS BY TREATMENT WITH POTASSIUM ACETATE: Am. Mineralogist, v.46, no. 1/2, p. 78-91, 8 figs., table, Jan.-Feb. 1961, 22 refs.

Grinding with K-acetate ($KC_2H_3O_2$) caused a lattice expansion to 14 Å not only for halloysite but good kaolinite, while the formation of the same complex by drying from a $KC_2H_3O_2$ solution was only observable for halloysite, hydrated or dehydrated without heat. Heating the 14 Å complex at 100°C. caused a collapse to 11.4 Å by dehydration. No comparable result was obtained for kaolinite by grinding with the other NH_4 and K salts which were effective in the formation of the halloysite complex. Also, no complex of $KC_2H_3O_2$ formed with some clay minerals, such as pyrophyllite, talc, antigorite, chrysotile, and chlorites.

The 14 Å complexes of kaolin minerals were subjected to washing with water and air-drying at R.H. 65%. The resulting spacings were 7 Å with good kaolinites, and 10 Å with halloysites, even if they had once dehydrated either with or without heat. The observed difference was interpreted in terms of the regularity in the arrangement of the structural layers affecting the orientation of interlayer water molecules.--Auth.

3-1928. Dunne, James A., and Paul F. Kerr. DIFFERENTIAL THERMAL ANALYSIS OF GALENA AND CLAUSTHALITE: Am. Mineralogist, v. 46, no. 1/2, p. 1-11, 6 figs., table, Jan.-Feb. 1961, 16 refs.

Differential thermal analyses have been conducted on both natural and artificial Pb-S-Se compounds. Thermal curves of 12 natural galenas exhibit a striking consistency regardless of the genetic associations of the minerals studied. In certain instances, limited (5-10° C.) variations from the over-all average peak temperature of 783± 2°C. appear, which seem to be related to lattice parameter differences.

A range of synthetic compounds at 10 molecular percent solid solution intervals from PbS to PbSe has been formed by pyrosynthesis. X-ray measurements of the series showing unidimensional lattice variation in relation to composition plot as a straight line. Thermal data, on the other hand, produce a more complex plot which may be interpreted in terms of both lattice energies and the nature of the observed reactions. DTA reaction temperatures are systematically related to cell dimensions in the range PbSe-$PbS_{0.7}Se_{0.3}$. DTA data taken from samples in the compositional range $PbS_{0.7}Se_{0.3}$-PbS are believed to be affected by incongruent anion behavior and surface oxidation effects. Data on pyrosynthesis reaction (formation) temperatures exhibit a fundamental and systematic relation to molar composition throughout the entire compositional range.--Auth.

3-1929. Born, L., and Erwin Hellner. A STRUCTURAL PROPOSAL FOR BOULANGERITE: Am. Mineralogist, v. 45, no. 11/12, p. 1266-1271, 4 figs., table, Nov.-Dec. 1960, 7 refs.

A structure for the subcell of boulangerite is proposed which explains the morphology (as needles) and shows the boundary between the "galenalike" and the "stibnitelike" structures of complex sulfides.--Auth.

3-1930. Straczek, John A., and others. STUDIES OF THE MANGANESE OXIDES. IV. TODOROKITE: Am. Mineralogist, v. 45, no. 11/12, p. 1174-1184, 3 figs., 5 tables, Nov.-Dec. 1960, 4 refs.

Todorokite is a very abundant manganese oxide mineral in many deposits in Cuba and has been noted from other localities. Six new analyses are given; they lead to the approximate formula

$$(Na, Ca, K, Mn^{+2})(Mn^{+4}, Mn^{+2}, Mg)_6O_{12}\cdot 3H_2O.$$

Electron diffraction data show the mineral to be orthorhombic, or monoclinic with β near 90°. The X-ray powder pattern is indexed on a cell with $\underline{a}$ = 0.75 Å, $\underline{b}$ = 2.849 Å, c = 9.59 Å, β = 90°. A differential thermal analysis curve is given.--Auth.

3-1931. Frondel, Clifford, and others. NEW OCCURRENCES OF TODOROKITE: Am. Mineralogist, v. 45, no. 11/12, p. 1167-1173, 2 figs., 2 tables, Nov.-Dec. 1960, 8 refs.

Chemical, X-ray, and other data are given for todorokite, $(Mn, Mg, Ca, Ba, Na, K)_2 Mn_5O_{12}\cdot 3H_2O$, from Charco Redondo, Cuba, Farragudo, Portugal, and Hüttenberg, Austria. Additional localities at Romanêche, France, Saipan Island, Bahia, Brazil, and Sterling Hill, New Jersey, are noted. Delatorreite of Simon and Straczek is identical with todorokite.--Auth.

3-1932. Katsura, Takashi, and Ikuo Kushiro. TITANOMAGHEMITE IN IGNEOUS ROCKS: Am. Mineralogist, v. 46, no. 1/2, p. 134-145, 4 figs., 5 tables, Jan.-Feb. 1961, 14 refs.

Titanomaghemite, an oxidized titanomagnetite having compositions near the $TiFeO_3$-Fe_2O_3 join or even within the $TiFe_2O_5$-$TiFeO_3$-Fe_2O_3 triangular field in the system TiO_2-FeO-Fe_2O_3, has been found in some Japanese igneous rocks. Microscopically the mineral can be distinguished from titanomagnetite by its bluish gray color in reflected light and the abundance of cracks. Titanomaghemite so far observed occurs largely in rocks in which olivine and hypersthene are partially or completely altered to chlorite and serpentine, but it occurs also in some unaltered lava flows. It is concluded that titanomagnetite crystallizing from magma is oxidized to produce titanomaghemite under a certain condition which may be easily obtained during the cooling process. It is not necessary to consider the special solid solution series between γ-$FeTiO_3$ and Fe_3O_4 in order to explain the formation of titanomaghemite in igneous rocks. The titanomaghemite possesses vacancies of 2 or 3 metal ions in a unit cell. The lattice parameters vary with the ratios Fe/(Fe+Ti) and 32(Fe+Ti)/0, and range from 8.359 to 8.419 Å. --Auth.

3-1933. Loughnan, F.C., and P. Bayliss. THE MINERALOGY OF THE BAUXITE DEPOSITS NEAR WEIPA, QUEENSLAND: Am. Mineralogist, v. 46, no. 1/2, p. 209-217, 4 figs., 3 tables, Jan.-Feb. 1961, 10 refs.

Chemical and mineralogical data for 3 bauxite profiles from the Weipa area, Queensland, Australia, indicate that the deposits have resulted from the intensive leaching of kaolinitic sandstones. Three zones, each characterized by the mineralogy, are demarcated within the profiles. It is considered that the bauxitization processes probably commenced in the lower to middle Tertiary and are continuing at present under a tropical, monsoonal climate.--Auth.

3-1934. Gude, A.J., 3d, and others WHEWELLITE AND CELESTITE FROM A FAULT OPENING IN SAN JUAN COUNTY, UTAH: Am. Mineralogist, v. 45, no. 11/12, p. 1257-1265, fig., 3 tables, Nov.-Dec. 1960, 4 refs.

Whewellite ($CaC_2O_4\cdot H_2O$) in 2 large crystals, yellow celestite, and several other minerals were found in vuggy openings along a fault in the Radon mine near Moab, San Juan County, Utah. This is the second reported occurrence of whewellite from North America, the first being from limestone concretions in Montana. Paragenetically whewellite is later than the celestite and its origin is believed related to associated carbonaceous material.--Auth.

3-1935. Clark, Joan R., and Mary E. Mrose. **VEATCHITE AND p-VEATCHITE: Am. Mineralogist, v. 45, no. 11/12, p. 1221-1229, fig., 3 tables, Nov.-Dec. 1960, 9 refs.**

Comprehensive single-crystal X-ray precession studies on type material of 2 strontium borate hydrates, veatchite and *p*-veatchite, show that despite striking similarities the 2 minerals can be distinguished by single-crystal X-ray diffraction patterns. Both minerals are monoclinic: veatchite A2/*a* (or A*a*), $a = 20.81$, $b = 11.74$, $c = 6.62_6$ Å (all ±0.3%), $\beta = 92°07' \pm 05'$ perfect cleavage parallel to dominant plate form {100}, optical orientation Z = *b*, X = *c*, Y∧*a* = 2°; *p*-veatchite P2_1/*m* (or P2_1), $a = 6.72_9$, $b = 20.70$, $c = 6.58_1$ Å (all ± 0.3%), $\beta = 119°40' \pm 05'$, perfect cleavage parallel to dominant plate form {010}, optical orientation Y = *b*, X = *c*, Z∧*a* = 29°40'. Indexed X-ray powder data, presented for both minerals, are inadequate for positive identification. Assumption of the chemical formula, $SrO \cdot 3B_2O_3 \cdot 2H_2O$, for each mineral yields the following comparison of calculated and observed densities (g. cm.$^{-3}$): veatchite 2.85_7 calc. (8 formula units per cell), 2.78 ± 0.03 obs.; *p*-veatchite 2.90_7 calc. (4 formula units per cell), 2.60-2.65 obs. Dimorphism is possible but not established by present evidence.--Auth.

3-1936. Mitchell, Richard S., and Richard F. Pharr. **CELESTITE AND CALCIOSTRONTIANITE FROM WISE COUNTY, VIRGINIA: Am. Mineralogist, v. 46, no. 1/2, p. 189-195, 4 figs., table, Jan.-Feb. 1961, 9 refs.**

Celestite and calciostrontianite occur in vugs in dolomite of the Cayuga group (Silurian) in a quarry 1/2 mi. E. of East Stone Gap.

Light blue, well developed celestite crystals average about 1 in. in length. Most crystals are elongated parallel to the *a* axis, and the {011} faces predominate. Vectorial etching is common. A blue fibrous crust of celestite was also observed.

The calciostrontianite occurs as radiating globular masses up to a half inch in diamater. A quantitative spectrographic analysis shows approximately 10% CaO. X-ray diffraction data show a significant departure from pure $SrCO_3$.--Auth.

3-1937. Mrose, Mary E. **VERNADSKITE DISCREDITED: PSEUDOMORPHS OF ANTLERITE AFTER DOLEROPHANITE: Am. Mineralogist, v. 46, no. 1/2, p. 146-154, 2 tables, Jan.-Feb. 1961, 7 refs.**

Vernadskite crystals from Vesuvius, Italy, are shown to be pseudomorphs of antlerite, $Cu_3(SO_4)(OH)_4$, after dolerophanite. Experimental work indicates that these pseudomorphs were formed by the action of moisture from fumaroles on crystals of dolerophanite.

Indexed X-ray powder data are given for synthetic and natural dolerophanite and antlerite.--Auth.

3-1938. Kohn, H. W., and Ben M. Benjamin. **RADIATION COLORATION OF SILICA MINERALS: Am. Mineralogist, v. 46, no. 1/2, p. 218-225, 2 figs., Jan.-Feb. 1961, 17 refs.**

Radiation produced color centers in both natural and synthetic silicas are associated with impurity atoms although, since impure silicas do not always form color centers upon irradiation, these impurities *per se* are not sufficient to cause coloration. For trivalent impurities the extent and type of coloration seems to depend more upon the manner of incorporation rather than the identity of the impurity atom, although the identity will naturally affect the type of center formed. The degree of general disorder may be important, but specific defects, especially hydroxyl ions associated with positive hole traps, should also be considered. The difference in behavior between some natural specimens and those prepared or treated in the laboratory makes it doubtful that some of these natural quartz specimens were originally colored by ionizing radiation.--Auth.

3-1939. Okamura, R. T., and J. C. Forbes. **OCCURRENCE OF SILICIFIED WOOD IN HAWAII: Am. Jour. Sci., v. 259, no. 3, p. 229-230, March 1961, ref.**

Samples of silicified wood have been collected from the littoral cone, Puu o mahana, and from a bed of ash on the SW. slope of Mauna Kea, Island of Hawaii. On Puu o mahana the silicified wood occurs plentifully in the uppermost 10 ft. of the cone; none has been observed in the overlying weathered Pahala ash. The wood appears as vertical tubelike concretions which presumably represent the roots of some plant that grew on the surface of the cone prior to or contemporaneous with the deposition of the Pahala ash. The wood ranges from about 1/4 in. to 2 1/2 in. in diameter, and pieces up to 2 ft. in length have been found. Chemically the material is opal consisting of 93.88% SiO_2, 4.15% H_2O^+, 0.64% H_2O^-, and 1.33% remainder.

Volcanic ash weathers rapidly and releases soluble silica. Plant materials, when embedded in ash, have more chance of becoming silicified before they disappear through complete decay than in any other matrix. In the case of the Hawaiian wood, the silica probably came from the overlying highly weathered Pahala ash. The Hawaiian material is of special interest because it indicates that a much less siliceous tholeiitic basalt ash also serves as a source of readily available silica.--A. C. Sangree.

3-1940. White, J. F., and J. F. Corwin. **SYNTHESIS AND ORIGIN OF CHALCEDONY: Am. Mineralogist, v. 46, no. 1/2, p. 112-119, 3 figs., 2 tables, Jan.-Feb. 1961, 23 refs.**

Synthetic chalcedony has anomalous properties similar to those of natural chalcedony. These properties have been explained by submicroscopic holes and inferred disordered regions between fiber interfaces. The properties and origin of synthetic chalcedony are compatible with these concepts.

The chalcedony was made by transformation of solid silica in the presence of hydrothermal solutions at moderate temperature and pressure. Chalcedony was not directly precipitated from solution, but formed only by transformation of silica glass or cristobalite. In general, no conversion took place in slightly acid solutions, while complete, rapid conversion occurred in slightly alkaline solutions. The transformation proceeds indirectly by way of cristobalite and keatite.

Chalcedony is regarded as a secondary, metastable, transitional phase. The peculiar properties differentiating chalcedony from ordinary quartz may be a result of nucleation and growth in solid material (silica glass, opal, silica gel, or cristobalite).--Auth.

3-1941. Zen, E-an. **MINERALOGY AND PETROLOGY OF THE SYSTEM Al_2O_3-SiO_2-H_2O IN SOME**

PYROPHYLLITE DEPOSITS OF NORTH CAROLINA: Am. Mineralogist, v. 46, no. 1/2, p. 52-66, 3 figs., table, Jan.-Feb. 1961, 18 refs.

The mineral assemblages from 7 pyrophyllite deposits in the Volcanic Slate belt of the North Carolina Piedmont were studied by X-ray and microscopic methods. These deposits are at Glendon, Robbins, Staley, Snow Camp, Hillsboro, Hager's Mountain, and Bowling's Mountain.

Six of the minerals found in these deposits belong to the ternary system Al_2O_3-SiO_2-H_2O: quartz, pyrophyllite, andalusite, kyanite, kaolinite, and diaspore. The following are 3-phase assemblages belonging to the ternary system: quartz-kaolinite-pyrophyllite; pyrophyllite-andalusite-quartz; and kaolinite-diaspore-pyrophyllite. All the observed relations, in detail, are consistent with the assumption of mutual equilibrium among the minerals. The occurrence of andalusite-kaolinite assemblage at Hillsboro but of pyrophyllite-diaspore at Staley suggest differences in physical conditions of metamorphism at these localities.

The prevalence of 3-phase assemblages indicates that H_2O behaved as a fixed chemical component during the formation of the pyrophyllite bodies. This conclusion is inconsistent with a hydrothermal-replacement origin for these bodies, as such a theory implies that H_2O belonged to an open system and thus was a mobile component. An alternative mode of origin, consistent with the mineralogical and geological data, starts with saprolite bodies on the weathered surfaces of the volcanic rocks. The saprolite was buried by later volcanic rocks and subsequently the entire sequence was metamorphosed; during recrystallization the saprolite bodies behaved as closed systems. Relative concentrations of Al_2O_3, SiO_2, and H_2O at different parts of each deposit account for the difference in mineral assemblages. The regional metamorphism was of low grade; nowhere was the almandite isograd reached.--Auth.

3-1942. Sun, Ming-Shan. DIFFERENTIAL THERMAL ANALYSIS OF SHATTUCKITE: Am. Mineralogist, v. 46, no. 1/2, p. 67-77, fig., 5 tables, Jan.-Feb. 1961, 6 refs.

The DTA curve of shattuckite from Ajo, Arizona, is characterized by a prominent endothermal peak with a false peak temperature at 774°C., and a small exothermal peak with a peak temperature of 980°C. Within the dehydration temperature range, shattuckite is decomposed gradually into cryptocrystalline tenorite, some cryptocrystalline α-quartz, and an unknown phase. The exothermal reaction is caused by the crystallization of α-cristobalite. All phases are identified by the X-ray powder diffraction.

Crystallization of tenorite begins at 675°C. and ends at 780°C. This is a strong exothermal reaction. However, an exothermal peak is obliterated completely by the endothermal dehydration reaction. At the same time, the shape of the dehydration endothermal peak is strongly skewed, and only a false endothermal peak is recorded on the graph. Some tenorite in the sample begins to decompose into cuprite at about 900°C. According to the total water content, the formula of shattuckite should be $3CuSiO_3 \cdot H_2O$. The accepted formula, $2CuSiO_3 \cdot H_2O$, is incorrect, because of an erroneous interpretation of loss of weight of the shattuckite sample by ignition.--Auth.

3-1943. Honea, Russell M. NEW DATA ON BOLTWOODITE, AN ALKALI URANYL SILICATE: Am. Mineralogist, v. 46, no. 1/2, p. 12-25, 4 figs., 5 tables, Jan.-Feb. 1961, 9 refs.

Boltwoodite is an alkali uranyl silicate with the composition $K(H_3O)UO_2(SiO_4) \cdot nH_2O$ where n is zero to one. Chemical analysis, recalculated after deducting impurities, gives SiO_2-14.8, UO_3-68.5, K_2O-9.4, Na_2O-0.4, H_2O-6.9, total 100.0%. The proposed formula is supported by infrared data, and the formula and other lines of evidence are shown to indicate a relationship to kasolite. Strongest lines of the X-ray powder pattern are 6.81 (10), 3.40 (9), 2.95 (8), 3.54 (7), and 2.91 (7). Optically biaxial negative with $nX = 1.668$-1.670, $nY = 1.695$-1.696, $nZ = 1.698$-1.703; 2V large, anomalous blue interference color, parallel extinction. Color pale yellow. Habit: radiating acicular to fibrous, and dense microcrystalline pseudomorphic aggregates. Hardness 3 1/2 to 4. Perfect (010) and imperfect (001) cleavage. Symmetry orthorhombic on basis of optical study, but may be monoclinic with b-axis elongation. Boltwoodite occurs as a secondary mineral coating fractures and cavities, and as pseudomorphs after uraninite. Twentyone localities representing a variety of geological environments are listed. Data are presented on the hydrothermal synthesis of the K, K + Na, and ammonium analogues of the mineral.--Auth.

3-1944. Hurlbut, Cornelius S., Jr., and John L. Baum. ETTRINGITE FROM FRANKLIN, NEW JERSEY: Am. Mineralogist, v. 45, no. 11/12, p. 1137-1143, 2 figs., 4 tables, Nov.-Dec. 1960, 8 refs.

Ettringite at Franklin, New Jersey, occurs as white to colorless crystals 2-3 mm. across with the only crystal form $\{10\bar{1}2\}$. The axial ratio determined from their measurement is $\underline{a}:\underline{c} = 1:0.001$. Specific gravity is 1.77 (meas.); 1.79 (cal.). Perfect $\{10\bar{1}0\}$ cleavage. Optically (−), $\omega = 1.491$, $\epsilon = 1.470 + 0.001$. After heating to 110°C., optically (+), $\omega = 1.538$ $\epsilon = 1.541$. Chemical analysis: CaO 27.3, Al_2O_3 5.1, SiO_2 3.1, SO_3 12.8, B_2O_3 3.2, H_2O 48.6, Total 100.1. A general formula can be written: $Ca_6(Si, Al, B)_3(SO_4)_2(O, OH)_{12}(OH)_4 \cdot 26H_2O$ of which there are 8 formula weights per unit cell. The unit cell dimensions are $\underline{a}_0 = 22.28$ Å, $\underline{c}_0 = 21.29$ Å giving a ratio $\underline{a}_0:\underline{c}_0 = 1:0.9556$.--Auth.

3-1945. Lapham, Davis M. NEW DATA ON DEWEYLITE: Am. Mineralogist, v. 46, no. 1/2, p. 168-188, 5 figs., 6 tables, Jan.-Feb. 1961, 19 refs.

The several subvarieties of deweylite from Cedar Hill, Pennsylvania, formed from aqueous, possibly colloidal, low-temperature solutions by the alteration of preexisting magnesium silicates in serpentinite. Fluorescent white deweylite, pseudomorphs of deweylite after aragonite, and Fe- and Ni-bearing varieties are described. Molecular water is characteristic of deweylite and is present in varying amounts. The ratio of tetrahedral cations to octahedral cations is approximately 1:1. The structure of deweylite is similar to that of antigorite, containing a superlattice probably in the a direction of about $8\ 1/2\underline{a}_0$. Line broadening is extreme and characteristic, and many of the antigorite reflections are weakly diffuse or absent. Analysis of the data suggests that Cedar Hill deweylite may be a dioctahedral modification of antigorite with an undulant character in the ab plane and containing crystallites on the order of a few hundred Angstroms. No single crystals or well crystallized samples of deweylite have been discovered.--Auth.

3-1946. Gay, P., and R.W. LeMaitre. SOME OBSERVATIONS ON "IDDINGSITE": Am. Mineralogist, v. 46, no. 1/2, p. 92-111, 6 figs., 4 tables, Jan.-Feb. 1961, 14 refs.

Specimens of "iddingsite" for many localities have been examined by X-ray, chemical, and optical methods in a study of the alteration of olivine to "iddingsite." This proves to be a continuous transformation, and although at any stage it is possible to recognize embryonic structures, the pseudomorph is throughout a disordered atomic arrangement and at no stage can it be assigned a definite structure or chemical composition or be regarded as a simple submicroscopic mineral intergrowth. The mechanism of the alteration appears to be one of cationic diffusion and replacement, the anion framework suffering little change; the presence of a high proportion of mobile H ions is probably an important factor. Some speculations are offered regarding the physical and chemical conditions under which alteration takes place.--Auth.

3-1947. Williams, Sidney A. A NEW OCCURRENCE OF ALLANITE IN THE QUIJOTOA MOUNTAINS, PIMA COUNTY, ARIZONA: Arizona Geol. Soc., Digest, v. 3, p. 47-51, map, 2 tables, 1960, ref.

Allanite was discovered in the E. flank of the Quijotoa Mountains, 2 mi. S. of Covered Wells. The deposit, of no economic significance, occurs as a roughly N.-S. zone cutting through quartz monzonite. The N. end of the deposit disappears in a spessartite intrusion which also cuts the quartz monzonite. The S. end of the zone was not defined, although it was traced for about 2 mi. along the strike Allanite is highly concentrated as disseminations and pods in the northernmost 100 yards of the zone. Petrographic and mineralogic relations are given.--From auth., p. 47.

3-1948. Slivko, M. N. MANGANESE TOURMALINES. Translated by Royer and Roger, Inc.: Internat. Geology Rev., v. 3, no. 3, p. 195-201, 3 figs., table, March 1961, 27 refs.

The role of Mn in the chemical composition and coloring of tourmaline is discussed. It is shown that Mn tourmaline-tsilaisite is similar to tourmaline-elbaite in composition and condition formation. The miscibility in the sherlite-elbaite-tsilaisite system is complete, but in the sherlite-dravite-tsilaisite system there is a gap between the dravite and tsilaisite, similar to the relationship between dravite and elbaite.

Mn may be present in tourmaline in the form of Mn^{2+} and Mn^{3+}. The pink coloring of the tourmaline is caused by Mn^{3+}. This conclusion has been drawn from data provided by many authors on the nature of pink coloring of tourmaline, the dyeing properties of Mn^{2+} and Mn^{3+}, the possibility of the existence of Mn^{3+} during the crystallization of pink tourmaline, and the distribution of Mn in differently colored tourmaline.--Auth.

3-1949. Winchell, Horace. REGRESSIONS OF PHYSICAL PROPERTIES ON THE COMPOSITIONS OF CLINOPYROXENES. II. OPTICAL PROPERTIES AND SPECIFIC GRAVITY: Am. Jour. Sci., v. 259, no. 4, p. 295-319, 6 tables, Apr. 1961, 66 refs.

New regression coefficients of 5 physical properties (n_x, n_y, n_z, Z/c, and G) on 15 variables of chemical composition in clinopyroxene $[ABC_2O_6 = (K, Na, Ca, Mn, Fe'', Mg) (Mn, Fe'', Mg, Ti, Fe''', Al) (Fe''', Al, Si)_2O_6]$, calculated by least squares from data in 155 selected published descriptions, yield new "best" estimates of the values of these properties for important compositions; the estimates of refractive index are statistically accurate to ±.005 or better at the 90% confidence level for all principal "end members" except johannsenite and jadeite, for which data are insufficient, or of insufficient accuracy. The standard deviations decrease as the composition approaches the over-all mean composition of the specimens used, reaching an optimum of ±.0008 for the refractive indices of the mean.

Best values and standard deviations for some "end members" are given. The remarkable success of the regressions in predicting optical properties of clinopyroxenes lends support to the hypothesis of linear, additive variation of these properties throughout the entire clinopyroxene system and thus to the suggestion that the system should be described as a single unit.--Auth.

Pt. 1 of this series was listed as GeoScience Abstracts 3-560.

3-1950. Pryor, Wayne Arthur, and Herbert D. Glass. CRETACEOUS-TERTIARY CLAY MINERALOGY OF THE UPPER MISSISSIPPI EMBAYMENT: Jour. Sed. Petrology, v. 31, no. 1, p. 38-51, 7 figs., 2 tables, March 1961, 16 refs.

An integrated stratigraphic, paleontologic, and petrologic study shows the presence of 3 general environments of deposition for the Cretaceous and Tertiary sediments of the upper Mississippi embayment: 1) fluviatile, 2) inner neritic, and 3) outer neritic. Prior petrologic studies have shown similar provenance features for all stratigraphic units involved.

X-ray diffraction analyses of 199 clay samples from the 3 environments and from all the stratigraphic units studied show kaolinite, illite, and montmorillonite as the dominant clay minerals, with small amounts of mixed-lattice and chloritic materials in a few samples. There are 3 clay mineral assemblages - one dominantly kaolinite, a second dominantly montmorillonite, and a third having nearly equal amounts of kaolinite, illite, and montmorillonite.

The clays of the Eocene (undifferentiated) formations, and of the Cretaceous McNairy and Tuscaloosa formations and the northern part of the Coffee formation are dominantly kaolinite; those of the Porters Creek, Clayton, and Owl Creek formations and the southern part of the Selma formation are dominantly montmorillonite; and those of the Coon Creek formation, the northern part of the Selma formation, and the southern part of the Coffee formation are kaolinite, illite, and montmorillonite in nearly equal amounts.

Clays deposited in the fluviatile environment are dominantly kaolinite, those in the outer neritic environment are dominantly montmorillonite, and those in the inner neritic environments are composed of nearly equal amounts of kaolinite, illite, and montmorillonite.

Segregation of clay minerals in the depositional environments is believed responsible for these variations in clay mineralogy. Diagenesis and variations in contributions from the source area are believed to be insignificant factors.--Auth.

3-1951. Bideaux, Richard A., and Sidney A. Williams. SOME NEW OCCURRENCES OF MINER-

ALS OF ARIZONA: Arizona Geol. Soc., Digest, v. 3, p. 53-56, 1960.

Sixty-two recently recognized mineral occurrences in Arizona are listed, of which 33 are previously unreported. Mineral associations, locality, and identifier, discoverer, or principal referent are given.--M. Russell.

3-1952. Erd, Richard C., and Seymour S. Greenberg. MINERALS OF INDIANA: Indiana, Geol. Survey, Bull. 18, 73 p., 2 figs., 3 tables, 1960.

Undisturbed Paleozoic sediments form the bedrock surface of Indiana. The most common minerals in these sediments are calcite, clay minerals, dolomite, glauconite, goethite, gypsum, hematite, limonite (hydrous iron oxides), quartz, and siderite. Found less abundantly are anhydrite, apatite, aragonite, barite, celestite, copiapite, epsomite, fluorite, marcasite, melanterite, millerite, pyrite, pyrrhotite, smythite, sphalerite, strontianite, S, and wad. These minerals occur in veins and cavities; along bedding, joint, and fracture surfaces and stylolite seams; and in geodes in limestones. Reported and observed locations and modes of occurrence are presented for each of the minerals except most clay minerals. The more unusual minerals that occur in glacial materials of Indiana, native Cu, diamond, galena, native Au, and native Ag, are described in detail.

A literature study was the basis for a brief discussion of the history of Indiana minerals. The present report questions the reported occurrences in Indiana of native Bi, graphite, malachite, moissanite, nitromagnesite, and stibnite.--Auth.

3-1953. King, Elbert A., Jr. TEXAS GEMSTONES: Texas, Univ., Bur. Econ. Geology, Rept. Inv., no. 42, 42 p., 20 figs., 6 pls., Feb. 1961, 14 refs.

The art of gem cutting has recently become a hobby for many Americans. The procedures and techniques used in gem cutting are illustrated and described. Texas gem minerals include amber, augite, beryl, celestite, diamond, epidote, fluorite, fossil wood, gadolinite, garnet, jet, labradorite, microcline, obsidian, opal, pearl, quartz (crystalline and cryptocrystalline varieties), sanidine, spinel, tektite (bediasite), topaz, tourmaline, turquoise. They are described in terms of composition, structure, hardness, specific gravity, luster, color, streak, cleavage, fracture, tenacity, diaphaneity, and refractive index. General localities are noted.--P. T. Flawn.

9. IGNEOUS AND METAMORPHIC PETROLOGY

See also: Geomorphology 3-1778; Structural Geology 3-1792; Stratigraphy 3-1803; Mineralogy 3-1932, 3-1941, 3-1947; Mineral Deposits 3-2024.

3-1954. Vistelius, Andrew B., and Oleg V. Sarmanov. ON THE CORRELATION BETWEEN PERCENTAGE VALUES: MAJOR COMPONENT CORRELATION IN FERROMAGNESIUM MICAS: Jour. Geology, v. 69, no. 2, p. 145-153, 2 tables, March 1961, 4 refs.

The method of elimination of distortion in correlation coefficient values between percentages is considered. This method has been applied in studying the correlation between major elements of ferromagnesium micas. It has been found that some elements in the 6-coordination group are correlated. In addition, separate elements in the 4-coordination ion group are correlated with elements of the 6-coordination ion group.--Auth.

3-1955. Macdonald, Gordon A. VOLCANOLOGY: Science, v. 133, no. 3454, p.673-679, 2 figs., table, March 10, 1961, 22 refs.

A review of the current problems in volcanology. Analysis of seismic waves shows that moving magma underlies many active volcanoes at the 40-60 km. level. At greater depths (100-200 km.) the geothermal gradient may approach the liquidus of basalts, so that a small local rise in temperature or a release of pressure could generate a magma. The energy release in eruptions is large 10^{16}-10^{25} ergs), but is only a small fraction of the total heat conducted to the earth's surface. The cause of the local concentration of energy in eruptions is still unknown. The constitution of the mantle may be known when the Mohole is drilled, thus solving another problem. The subsurface structure of volcanoes indicates that magma is often stored in a lenticular chamber 4-7 km. below the surface.--F. P. Glasser.

3-1956. Wargo, Joseph G. A PROPOSED CLASSIFICATION SCHEME FOR PYROCLASTIC ROCKS: Arizona Geol. Soc., Digest, v. 3, p. 71-74, 4 figs., 1960, 5 refs.

A scheme for the classification of pyroclastic rocks is proposed, which considers the following elements: 1) amount of crystal, lithic, and vitric constituents in the rock and, 2) size of the crystal, lithic, and vitric constituents. These factors are used to construct a crystal-lithic-vitric plot and to determine which of 3 rock names is applicable. The CLV plot provides the descriptive prefix to the rock name. Other information on composition and special textural features can also be prefixed.

A pyroclastic rock is classified in the following manner: 1) Determine the relative percentages of the crystal, lithic, and vitric constituents (C+L+V - 100%). 2) Determine the correct field on the CLV triangle with the information from "1". 3) Estimate or measure the size of the particles. If 90% or more of the volume is made up of particles which are over 4 mm. in diameter, the rock name is breccia. If 90% or more of the volume is made up of particles which are less than 4 mm. in diameter, the rock name is tuff. If the particles have a great range in size (e.g. 40% over 4 mm., 60% under 4 mm.) the rock name is tuff-breccia. 4) Prefix the CLV field determined in "2" to the rock name in "3" for a complete descriptive term. 5) Prefix compositional and textural terms if desired.--Auth. summ.

3-1957. Marlowe, James I. DIATREMES AND A RING INTRUSION ON THE SAN CARLOS INDIAN RESERVATION: Arizona Geol. Soc., Digest, v. 3, p. 151-154, 1960, 8 refs.

Diatremes in the San Carlos area, Arizona, show marked resemblances to those in the Navajo-Hopi country. A crude lineation of vents indicates intrusion along a weak zone or break in the basement rocks beneath the Safford Valley. Fragments of metamorphosed rhyolite contained in the Salt creek diatreme were probably derived from depths at which conditions promoting plastic deformation prevail. Variations in aspect between diatremes are attributed to differences in depth of erosion and in degree of development. The San Carlos ring intrusion is the result of dike formation along a ring fracture caused by the upward stress of a magma column. Doming of the dislocated plug of sediments was followed by gaseous or explosive vent drilling through apical fractures.--Auth. concl.

3-1958. Taylor, Omer J. CORRELATION OF VOLCANIC ROCKS IN SANTA CRUZ COUNTY, ARIZONA: Arizona Geol. Soc., Digest, v. 3, p. 87-91, pl., table, 1960, 6 refs.

Study of the volcanic rocks in Santa Cruz County has been made which indicates many similarities of sequence and structure in the volcanic rocks of the Atascosa, Tumacacori, Santa Rita, Patagonia, and Mustang mountains. The volcanic rocks of the Tucson Mountains to the N. of Pima County also show similarities to those in the ranges of Santa Cruz County. Stratigraphic columns constructed for the volcanic rocks of each range show the generalized sequence in each case to be: Cretaceous(?) andesite and rhyolite; Tertiary andesite, rhyolite, tuff, rhyolite-latite, and andesite; and Quaternary(?) basalt.--M. Russell.

3-1959. Boyd, F. R. WELDED TUFFS AND FLOWS IN THE RHYOLITE PLATEAU OF YELLOWSTONE PARK, WYOMING: Geol. Soc. America, Bull., v. 72, no. 3, p. 387-426, 11 figs., 6 pls., 10 tables, March 1961, 57 refs.

The rhyolite plateau in Yellowstone Park is made up of flows and welded tuff with subsidiary rhyolite domes, basalt, and rhyolite-basalt mix-lava. The 2 most important units are the Yellowstone tuff, exposed over 600 sq. mi. within the park, and a group of younger flows, the Plateau flows, which cover 1,000 sq. mi. in the Madison, Central, and Pitchstone plateaus.

The Plateau flows occupy a tectonic basin rimmed by Yellowstone tuff and older rocks in central and southwestern Yellowstone Park. Individual flows range up to 1,000 ft. in thickness and cover areas up to at least 100 sq. mi. Surficial features, including vent domes, are locally well preserved. Exposed portions of these flows are, for the most part, banded obsidian and perlite and breccias formed by incorporation of fragments of pumiceous crust in the moving flows.

The Yellowstone tuff is welded to obsidian at its base and grades upward through indurated, lithoidal rhyolite to loose ash at the top of an uneroded section. Probably all the Yellowstone tuff was erupted in a single rapid series of eruptions from dispersed vents.

Textural and structural evidence suggests that the Yellowstone tuff was emplaced as pyroclastic flows. A thermodynamic analysis of this type of eruption is given. Energy changes within the conduit and during emplacement are evaluated. The minimum temperature at which rhyolite glass will weld, determined experimentally, is approximately 600°C. The data of Tuttle and Bowen are used to fix the range of initial magma temperature. Welding in the Yellowstone tuff can be explained if the tuff was emplaced as pyroclastic flows and if the magma contained less than about 4% H_2O at the start of the eruption.--Auth.

3-1960. Pogonya-Stefanovich, Yu. F., and V.G. Perelomova. DEVONIAN VOLCANIC NECKS IN THE NORTHWESTERN MINUSINSK DEPRESSION: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 4, p. 80-82, pub. 1960.

Describes ancient necks of volcanoes which were active in the Devonian. Thick blankets of effusive rocks in Lower and Middle Devonian deposits were formed by the successive eruption of these volcanoes. The necks were filled with rocks of similar composition, texture, and structure with those found in the effusive rocks. Three more-or-less sharply defined zones were found in each neck, each zone filled with different rock. The study of accumulated rocks showed that they were formed by successive eruptions of these volcanoes, and the composition of the magma erupted varied during the same cycle of volcanic activity.--From LC.

3-1961. Campbell, Finley A. DIFFERENTIATION TRENDS IN THE ICE RIVER COMPLEX, BRITISH COLUMBIA: Am. Jour. Sci., v. 259, no. 3, p. 173-180, 5 figs., 2 tables, March 1961, 16 refs.

Four phases of the complex (jacupirangite, ijolite, nepheline syenite, and sodalite syenite) were studied from the viewpoint of their chemical variation. If one goes from the first-formed jacupirangite to the last-formed sodalite syenite, CaO, FeO, Fe_2O_3, MgO, and TiO_2 decrease, whereas SiO_2, Al_2O_3, Na_2O, K_2O, and volatile content increase.

A tentative diagram for the system SiO_2-$NaAlSiO_4$-$KAlSiO_4$ at a water pressure of 1,000 kg./cm.^{2} is used to study the differentiation path. Jacupirangite lies well above the diagram due to its high CaO and MgO content. Ijolite is at or near the liquidus of the system, and nepheline syenite falls in the cotectic trough between the feldspar and nepheline fields. Sodalite syenite does not appear to lie at the ternary eutectic in the position expected of the last differentiate.--Auth.

3-1962. Jackson, Everett D. PRIMARY TEXTURES AND MINERAL ASSOCIATIONS IN THE ULTRAMAFIC ZONE OF THE STILLWATER COMPLEX, MONTANA: U.S. Geol. Survey, Prof. Paper 358, 106 p., 92 figs. incl. illus., maps, diags., graphs, 10 tables, 1961, 100 refs.

The Ultramafic zone of the Stillwater complex, which has an average stratigraphic thickness of about 3,500 ft. may be subdivided into 2 members: the Peridotite member, which forms the stratigraphically lower two-thirds of the zone, and which is composed of conformably interlayered harzburgites, chromitites, bronzitites, and dunites; and the Bronzitite member, which forms the upper one-third of the zone and which is composed of a single thick layer of bronzitite.

The constituent grains of the layered rocks of the Ultramafic zone may be divided into 2 groups on the basis of texture: those that represent the primary precipitate that crystallized in the magma column, settled, and accumulated on the floor of the magma chamber; and those that represent the interprecipitate material that crystallized in place in the pore spaces surrounding the primary precipitate. These simple relations have, however, been complicated in many rocks by reaction replacement and secondary enlargement.

The rocks are believed to have formed during crystallization of a single saturated basalt magma by accumulation of early crystal precipitates that fell, layer on layer, to the floor of the magma chamber and were enlarged or cemented after deposition by the magma from which they crystallized. The textures and structures of the rocks suggest that the magma near the floor of the intrusion was essentially stagnant throughout the crystallization of the Ultramafic zone, that crystallization of the primary precipitate took place near the bottom of the magma chamber, and that the cyclical compositional layers directly reflect changing crystallization products of the magma with time.--Auth.

3-1963. Sell, James D. DIABASE AT THE MAGMA MINE, SUPERIOR, ARIZONA: Arizona Geol. Soc., Digest, v. 3, p. 93-97, fig., table, 1960, 12 refs.

This paper reviews the evidence and presents new data concerning the mode of emplacement of the pre-Devonian, massive, sill-forming diabase in the Magma mine area. It is concluded that assimilation by the intruding diabase is not a factor in explaining the absence of the Troy quartzite [Upper and Middle Cambrian] and Mescal limestone [Precambrian] in the stratigraphic sequence.--M. Russell.

3-1964. Anthony, John W. A NOTE ON THE PROBABILITY OF ASSIMILATION OF ROCKS INTRUDED BY THE CENTRAL ARIZONA DIABASE: Arizona Geol. Soc., Digest, v. 3, p. 99-102, fig., 1960, 4 refs.

Consideration of some basic petrologic principles suggests that, owing to the relative compositions of rocks and magma involved, one should not expect extensive assimilation of sedimentary units such as the Troy quartzite [Upper and Middle Cambrian] and Mescal limestone [Precambrian] by the magma which formed the central Arizona diabase.--Auth. concl.

3-1965. Afanaseva, L. K. THE KHYUTA GABBRO-DIABASE INTRUSION IN THE IMANGDA RIVER VALLEY (NORTHWESTERN PART OF THE SIBERIAN PLATFORM): Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 7, p. 21-25, table, pub. 1961, 4 refs.

The intrusion, more than 10 km. long, is composed of different varieties of gabbro-diabase occurring in Upper Silurian limestone. The main mineral components are the basic plagioclase, pyroxene, and olivine. Plagioclase forms masses of regular crystals mainly of labradorite. Pyroxene occurs in the form of augite, and its composition is almost the same in the whole intrusion. It oscillates from $Wo_{38}En_{42}Fe_{20}$ to $Wo_{41}En_{38}Fe_{20}$. Olivine is evenly distributed. All varieties of the intrusion are similar chemically and are characterized by an absence of differentiation of the intrusion. Their composition is very near to the average chemical composition of the world basalt, according to R. Deli. Although the author stresses the high degree of metamorphosis of the gabbro-diabase, basically they all have been formed from primary magma which crystallized gradually. Intratelluric formations connected with the first crystallization phases are represented by the rounded grains of olivine associated with the lowest strata of the intrusion, when an olivine gabbro-diabasic stratum was formed. Grains of this early olivine are enclosed in the plagioclase and pyroxene, proving thus their earlier origin.--From LC.

3-1966. Muir, I.D., and C.E. Tilley. MUGEARITES AND THEIR PLACE IN ALKALI IGNEOUS ROCK SERIES. With Chemical Analyses by J. H. Scoon: Jour. Geology, v. 69, no. 2, p. 186-203, 7 figs., pl., 12 tables, March 1961, 30 refs.

Mugearite as a petrographic and petrogenetic unit is reviewed in the light of new analyses of the type and new data on the composition and optical properties of its feldspar solid solutions and clinopyroxene phases. The feldspar studies reveal lime anorthoclase as a prominent modal mineral. The place of mugearite in igneous rock series is discussed, especially in relation to its development in Hebridean and Hawaiian volcanic successions.--Auth.

3-1967. Rogers, John J. W. ORIGIN OF ALBITE IN GRANITIC ROCKS: Am. Jour. Sci., v. 259, no. 3, p. 186-193, 4 figs., March 1961, 10 refs.

Albite in granites commonly occurs adjacent to K feldspar, either as rims on oligoclase or as small scattered grains. The albite was not derived either from adjacent K feldspar or from more calcic plagioclase and appears to have formed roughly synchronously with the K feldspar. Consequently, the albite appears to be a product of direct crystallization during the later stages of magmatic solidification.--Auth.

3-1968. Wilshire, H. G. SEDIMENTARY XENOLITHS AND DOLERITE PATCH PEGMATITES FROM AN ANALCITE BASALT INTRUSION: Am. Jour. Sci., v. 259, no. 4, p. 260-279, 9 pls., table, Apr. 1961, 35 refs.

[At Peats Ridge, N. of Sydney, Australia], reaction of sandstone and shale xenoliths with alkali basalt produced trachyte, dolerite, and dolerite-pegmatite modifications adjacent to the xenoliths. Reaction products are shown to represent modified host magma and to correspond chemically to possible differentiates of uncontaminated alkali basalt. The interplay of several processes prevents quantitative evaluation of the contribution of each to differentiation, but the following sequence of events is postulated to explain the origin of reaction products: upon immersion of cold xenoliths in the melt, a thermal gradient caused migration of alkali-bearing magmatic volatiles towards the xenoliths. At the same time the xenoliths were degassed, the effect of both events being a high concentration of volatiles in the host basalt surrounding the xenoliths. The consequent reduction of melting ranges of primary minerals caused resorption of crystals already present in the volatile enriched magma and set up concentration gradients between this and the surrounding basalt. The effect of these gradients was to cause outward migration of elements (mainly Mg and Ca) combined in early-formed minerals of the host rock. Similar concentration gradients existed towards the xenoliths, and reaction products surrounding sandstone xenoliths may be entirely explained by crystallization of diopside and plagioclase within the periphery of xenoliths and additions of MgO to cores of xenoliths. Shale xenoliths, however, have no pyroxene coronas, and there was no significant addition of MgO to cores or margins although pegmatite and trachyte reaction products are well developed. Relatively large losses of SiO_2 from xenoliths have not altered the undersaturated trend of reaction products.

Volatile transport of alkalis began at the time of vesiculation in ordinary basalt, probably contributed to alkali enrichment in reaction products, and continued into the post-consolidation hydrothermal stage. The latter, accompanied by hydrothermal alteration of olivine and plagioclase, probably added to the chemical trends expressed in the primary mineralogy of reaction products.

Some pegmatites are believed to be unrelated to xenoliths, but similar diffusion processes, with volatiles concentrated by shearing along curved flow planes during emplacement, are invoked to explain them.--Auth.

3-1969. Komarov, P.V. RELATION BETWEEN THE FORMATION OF MAGNESIAN SKARNS AND GRANITIZATION: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 5, p. 74-84, 7 figs., 2 tables, pub. 1960, 26 refs.

The Zheleznyy Kryazh Fe deposits in the eastern Transbaikal region are of contact-metasomatic origin. They are situated in the zone of contact of Kutomara Variscan granitoids with lower Paleozoic sedimentary rocks. These metamorphosed rocks form a residual block of different dimensions in the upper part of the granitoid massif. Their lower parts are composed of hornfelses, magnesian and calcareous skarns and quartzites, and in their upper parts, chloritized sandy-argillaceous slate. Granitoids have clear intrusive contacts with the metamorphosed sedimentary blocks. Prior to the metamorphism, the lower parts were composed of sandstone, interbedded with sandy-argillaceous and carbonate-argillaceous slate. As a result of metamorphic and metasomatic process, these slates and sandstones were transformed into various hornfelses and quartzites. Most of the interbedded argillaceous slate was transformed into magnesian and calcareous skarns, which later were mineralized. The calcareous pyroxene-garnet skarns were of postmagmatic origin. In some places, they also replaced the magnesian skarns, proving to be of later origin. In some places magnesian skarns were intersected by dikes of granite-aplites and diorite-porphyrites partly replaced by calcareous skarns. These dikes were formed after the magnesian skarns but earlier than the calcareous skarns.

The injection of granitoids is observed in magnesian skarns and in the diopside-plagioclase rocks surrounding the skarns. A distinct metasomatic zonality in the magnesian skarns surrounding the hybrid granitoids is also observed: a granitoid diopside or diopside-spinel zone and a forsterite or forsterite-spinel zone. Granitoids in contact with magnesian skarns have no traces of metasomatic change.

The author gives the result of the analysis of hybrid granitoids, showing changes in their chemical composition occurring in the interaction of granite magma with sedimentary rocks. He considers the granitization process to be an infiltrational magmatic replacement of enclosing rocks. There is an intermediate stage of diffusion or melting of enclosing rocks, and the summary composition of the melt equals the eutectic composition for granitoids. One peculiarity of granitization process is the formation, during the magmatic stage, of magnesian skarns of the type at Zheleznyy Kryazh. Magmatic solutions of the infiltration type conditioned the development of granitization in dolomites, and, as a result, along with the formation in exocontacts of magnesian skarns, hybrid granitoids of increased basicity and alkalinity were formed in the endocontact zone. Increased alkalinity is related to the increased activity of alkali in the magmatic solutions as a consequence of its (alkali) interaction with dolomites. Such increase of alkalinity permits the distinguishing of the magmatic infiltrational replacement (granitization) from the phenomenon of assimilation, which also occurred in the Zheleznyy Kryazh deposits and caused the formation of granitoids of greater basicity.--From LC.

3-1970. Butakova, E. L. THE ROLE OF METASOMATISM IN THE FORMATION OF ALKALINE ROCKS. Translated by Royer and Roger, Inc.: Internat. Geology Rev., v. 3, no. 3, p. 187-194, 8 illus., March 1961, 2 refs.

Various processes of metasomatism, such as biotitization, aegiritization, and nephelinization, control the ultimate appearance of rocks just as much as magmatic stages of their development. These processes have been brought to light in small composite intrusions in the northern part of the Siberian shield. The aegiritization and nephelinization reconstitute melanocratic rocks with nonalkaline pyroxene into mesocratic rocks with alkaline pyroxene. Of great interest is the conversion of dolerite at the contact with an alkaline intrusion into a rich nepheline rock, which retains vestiges of a poikilophitic texture. The investigation showed that metasomatism is involved in formation of alkaline rocks. Such rocks as carbonates were evidently formed here through the metasomatism of alkaline and nepheline syenite.--Auth.

3-1971. Rozentsvit, A.O. HYDROTHERMAL METASOMATISM OF PROTEROZOIC ROCKS IN THE OLEKMA-VITIM HIGHLANDS: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 5, p. 60-73, 7 figs., 6 tables, pub. 1960, 7 refs.

This paper describes the metasomatically altered Proterozoic rocks in the Olekma-Vitim highlands, affected by albitization, biotitization, and K-feldspathization. These processes took place in sedimentary rocks previously subjected to contact metamorphism. In a number of instances, the character of alteration depended on the lithologic composition of the original rocks. The metasomatism was accompanied by an extensive migration of the components; a relationship is noted between the addition of individual components in some rocks and their leaching from others.--Auth.

3-1972. Chodos, Arthur A., and Celeste G. Engel. FLUORESCENT X-RAY SPECTROGRAPHIC ANALYSES OF AMPHIBOLITE ROCKS: Am. Mineralogist, v. 46, no. 1/2, p. 120-133, 6 figs., 6 tables, Jan.-Feb. 1961, 11 refs.

Fluorescent X-ray spectrographic analyses have been made for the oxides Fe_2O_3, CaO, MgO, K_2O, TiO_2, and MnO on 27 samples of amphibolite rock. The amphibolites vary appreciably in mineralogical composition but all have a chemical composition approximating that of a saturated basalt. Variations in mineralogy are from hornblende-andesine amphibolites to 2 pyroxene-labradorite-hornblende gneisses with 0.2 to 5.0% opaque minerals.

Mean deviations of the fluorescent X-ray spectrographic analyses from classical wet chemical analyses in percent of the amount reported are: Fe_2O_3, 3.1; CaO, 1.3; MgO, 3.0; K_2O, 3.2; TiO_2, 3.2; and MnO, 7.7. Precision of the analyses is equivalent to, or better than, that achieved by wet chemical methods.

Preliminary work indicates equivalent precision can be obtained for most common rocks and minerals. --Auth.

3-1973. Moore, James G., and Clifford A. Hopson. **THE INDEPENDENCE DIKE SWARM IN EASTERN CALIFORNIA: Am. Jour. Sci., v. 259, no. 4, p. 241-259, 11 figs., 2 tables, Apr. 1961, 22 refs.**

A dike swarm up to 15 mi. wide and at least 85 mi. long cuts northwestward across the Sierra Nevada, Inyo Range, and Argus Range in eastern California. The dike rocks range from lamprophyre to granodiorite porphyry, the more mafic types predominating. The dikes are probably of Cretaceous age, for they intrude some granitic plutons of the Cretaceous Sierra Nevada batholith but are truncated by others. The dikes in the Sierra Nevada were metamorphosed by the younger granitic intrusives. In the Inyo and Argus ranges the dikes are hydrothermally altered, but otherwise unmetamorphosed.

Two sequences of granitic intrusion in the Sierra Nevada batholith (Mount Pinchot quadrangle) can be separated by the dike swarm. Each sequence apparently began with the emplacement of mafic granodiorite and concluded with alaskite; succeeding intrusions in each sequence were progressively more felsic. Two cycles of differentiation seem indicated. Chilled dike margins where the swarm cuts earlier plutons indicates that a significant time interval separated emplacement of pre-dike and post-dike plutons.

The dike swarm shows no apparent offset where it crosses Owens Valley. This argues against suggested major strike-slip faulting along the line of Owens Valley since Cretaceous time.--Auth.

10. SEDIMENTARY PETROLOGY

See also: Geomorphology 3-1772, 3-1773, 3-1780; Geochemistry 3-1882, 3-1902; Mineralogy 3-1950; Igneous and Metamorphic Petrology 3-1954; Mineral Deposits 3-2030; Fuels 3-2084.

3-1974. Hulsey, J.D. **RELATIONS OF SETTLING VELOCITY OF SAND SIZED SPHERES AND SAMPLE WEIGHT: Jour. Sed. Petrology, v. 31, no. 1, p. 101-112, 11 figs., 3 tables, March 1961, 9 refs.**

The fall velocities of the boundaries of a series of well sorted samples of sand sized glass spheres were determined in a modified Emery type settling tube for the purpose of measuring the changes in mass fall velocities with changes in sample weights. Fall velocities of the faster falling, larger diameter spheres forming the leading boundary in each sample were found to increase with sample weight. Fall velocities of smaller spheres forming the slower or trailing boundary were found to decrease with increasing sample weights. Over the median diameter range of 0.784 to 0.383 mm. these velocity changes appeared to be relatively independent of particle diameters, but at smaller median diameters the relative changes in velocity increased with decreasing size. From the weight-velocity relationships, it was shown that fall velocities achieved by masses of spheres depend upon the amount of sample used. Boundary velocities were attributed to certain particle diameters to provide a measure of the effects of the falling system on given sized spheres. It appeared further that the velocity of a given particle settling in a sample depends upon the size limits and the sorting of the sample. It was concluded that settling methods of analysis of sands do not give an accurate picture of size distribution in terms of sedimentation radii if the fall of the particles creates turbulence in the system.--Auth.

3-1975. Sternberg, R. W., and Joe S. Creager. **COMPARATIVE EFFICIENCIES OF SIZE ANALYSIS BY HYDROMETER AND PIPETTE METHODS: Jour. Sed. Petrology, v. 31, no. 1, p. 96-100, 3 figs., table, March 1961, 3 refs.**

A large sample of silt and clay was divided into 9 subsamples, with concentrations increasing from 3 g./l. to 25 g./l. These subsamples were first subjected to the hydrometer analysis, after which they were shaken and re-analyzed by the pipette method. The results of the 2 analyses were then compared.

Within a moderate range of silt and clay concentration (6 to 24 g./l.), the analyses gave similar results for the 5ø through 9ø size-grades. With concentrations of less than 6 g./l., the pipette analysis was superior; with concentrations greater than 24 g./l., the hydrometer analysis was more efficient. Within the range of concentrations studied, however, the pipette method gave better over-all results.--Auth.

3-1976. Ostrom, Meredith E. **SEPARATION OF CLAY MINERALS FROM CARBONATE ROCKS BY USING ACID: Jour. Sed. Petrology, v. 31, no. 1, p. 123-129, table, March 1961, 15 refs.**

Various chemical methods of freeing the clay minerals that occur in limestones and dolomites have been used without regard to the effect the chemicals might have on the properties and structures of these clay minerals.

A procedure is here suggested that will accomplish the separation without significantly affecting the character of randomly interstratified illite-montmorillonite, chlorite, illite, or kaolinite, as shown by their X-ray diffraction diagrams.

The limestone or dolomite is treated at room temperature with acetic acid (less than 0.3 molar) or hydrochloric acid (0.11 molar). The weaker the acid concentration the greater the possibility that the clay minerals will be unchanged. Some carbonate rocks must be present throughout the period of acid treatment.--Auth.

3-1977. Botvinkina, L. N. **MORPHOLOGICAL CLASSIFICATION OF BEDDING IN SEDIMENTARY ROCKS: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 6, p. 13-30, 8 tables, pub. 1961, 25 refs.**

The types and causes of bedding are described, and a morphologic classification is proposed. A stratum can contain one or more beds, and a bed can contain a series or a group of layers. Sometimes the layers form packs of layers, packs of layers form a series of packs, and several series of packs form a bed. The formation of beds is connected with the change of sediment-forming factors caused by different conditions, whereas the formation of layers is conditioned by a regular "pulsation" of sediment-forming factors, always under the same facies conditions.

A pack of layers is a group of layers connected by a tendency to change thickness or composition similar to changes in neighboring groups. A series of layers is a group of layers of the same type, similar in structure, composition, thickness, and occurrence. The author describes the connection between the character of bedding and the mechanism of formation of sediments, which conditions the difference of their features and structures. In general, in all sedimentary rocks bedding is the direct result of settling of sediments or of their redistribution after settling. A scheme of basic elements of bedding is presented. The basic feature for the morphologic classification of bedding is the position of layers in relation to the general bedding plane, and the author singles out 3 basic bedding types - sloping, wavy, and horizontal, as well as 2 intermediate types - slanting-wavy and horizontal-wavy. She describes different variations and subtypes of bedding.--From LC.

3-1978. Popov, V.M. DIAGENETIC DISLOCATIONS OF THE BEDDING AND LAYERING OF THE ORE-BEARING ROCKS OF THE DZHEZKAZGANSKAYA SUITE: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 6, p. 31-46, 15 illus., pub. 1961, 7 refs.

This article describes the varieties of bedding textures that have been formed in the ores of Dzhezkazgan during sedimentation and diagenesis of the primary ore-bearing deposit. The diagenetic dislocations of the bedding and layering in the ores, the types of interformational sedimentary breccias, and the nature of the mineralization in them are examined. New facts are advanced to explain the conditions of formation and genesis of the Dzhezkazgan ores; the author believes that these leave no room to doubt the primary sedimentary nature of the ore mineralization of this deposit.--Auth.

3-1979. Kelling, G., and E. K. Walton. FLOW STRUCTURES IN SEDIMENTARY ROCKS: A DISCUSSION: Jour. Geology, v. 69, no. 2, p. 224-225, March 1961, 8 refs.; Reply, by J. E. Prentice, p. 225-226.

Discussion of GeoScience Abstracts 2-934.

3-1980. Rybakov, F.F. STYLOLITES IN THE VOLGA REGION: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 4, p. 87-89, table, pub. 1960.

Stylolites are small structures occurring in sedimentary rocks, especially in limestone, up to 20-25 cm. high and 10-12 cm. in diameter, in variegated shapes. In the Volga region they are mostly found in the Paleozoic sedimentary strata. The author describes different varieties of stylolites, but cannot advance a theory explaining their occurrence or origin. Presumably stylolites were formed during, rather than after, the formation of sedimentary strata.--From LC.

3-1981. Ramsay, John G. THE EFFECTS OF FOLDING UPON THE ORIENTATION OF SEDIMENTATION STRUCTURES: Jour. Geology, v. 69, no. 1, p. 84-100, 17 figs., table, Jan. 1961, 17 refs.

The primary orientation of sedimentation structures in folded regions is often considerably modified as a result of flexure, shear, and compression during the production of the folds. The effects of these various deformation processes are described, and techniques are suggested by which the initial orientation of the structures can be established. Such techniques may be of use in establishing paleocurrent (or paleomagnetic) directions in tilted, folded, or deformed strata.--Auth.

3-1982. Grossgeim, V.A. SOME PETROGRAPHIC AND PALEOGEOGRAPHIC FEATURES OF SEDIMENTS IN GEOSYNCLINAL FORMATIONS (AS DEMONSTRATED IN THE CAUCASIAN FOLD PROVINCE): Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 7, p. 51-62, 5 maps, pub. 1961, 26 refs.

This paper describes the mineralogic composition, granulometry, and texture of a number of principal formations in the outer zone of the Caucasian geosynclinal province and in foredeeps which fringe it - the slate, flysch, and the lower and upper molasse. The slates had a source of terrigenous material in the direction of a platform land mass; interior uplifts played a very small part in sedimentation. The flysch basins were fed exclusively from interior uplifts. During the formation of the lower molasse, material came to foredeeps first from the platform, then from the ever-growing interior uplifts. Finally, the upper molasse is marked by the great amount of coarse terrigenous material which arrived from the rapidly rising greater Caucasus mountain system (an "interior uplift").--Auth. abs. & summ.

3-1983. Niyogi, Dipankar. PATTERN OF TALCHIR SEDIMENTATION IN BURHAI GONDWANA BASIN, BIHAR, INDIA: Jour. Sed. Petrology, v. 31, no. 1, p. 63-72, 5 figs., table, March 1961, 21 refs.

A detailed sedimentary environmental study has been attempted in upper Carboniferous (Talchir series) sediments in a small basin in eastern India. The lowest sediments were laid down in front of a glacier during the extensive upper Carboniferous glacial epoch and represent glaciofluvial outwash sediments varying laterally into glaciolacustrine sediments. Fourteen boulder conglomerate bands have been identified and interpreted as representing oscillations of the glacial front. Typical varved silts with a large number of rafted pebbles and boulders have been seen. These sediments are overlain by siltstones and silt-shales which probably represent valley train sediments, the glacier having receded. Current flow in these and lower beds was consistently from the WSW. where the glacier existed. Chloritic arkoses found further up the column are probably stream deposits.

The question of the origin of the Gondwana basins as well as of the absence of tillite in Burhai and 4 nearby basins is discussed.--Auth.

3-1984. Pollack, Jerome M. SIGNIFICANCE OF COMPOSITIONAL AND TEXTURAL PROPERTIES OF SOUTH CANADIAN RIVER CHANNEL SANDS, NEW MEXICO, TEXAS AND OKLAHOMA: Jour. Sed. Petrology, v. 31, no. 1, p. 15-37, 15 figs., 6 tables, March 1961, 32 refs.

Size distribution parameters and mineralogical composition of South Canadian River channel sands remain essentially constant over approximately 650 mi. of river distance. Mean roundness, mean sphericity, and mean shape factor values of some minerals in the channel sediment increase downstream, while these values decrease for others. However, most minerals show no significant variation in these properties either downstream or between size grades. Quartz-feldspar ratio increases significantly downstream in only 2 size grades.

A brief review of size distribution and particle morphology parameters is given.--Auth.

3-1985. McCammon, Richard B. **VARIATION IN PEBBLE COMPOSITION OF WISCONSIN OUTWASH SEDIMENTS IN THE WABASH VALLEY, INDIANA: Jour. Sed. Petrology, v. 31, no. 1, p. 73-79, 4 figs., table, March 1961, 10 refs.**

Variation in the pebble composition of Wisconsin glacial outwash sediments in the Wabash Valley has been significantly controlled by the influx of rock fragments supplied by the local Paleozoic bedrock. Dolostone, the dominant rock type, and limestone were derived from the Silurian and Devonian formations that crop out in northern Indiana. Limestone was also furnished by the Mississippian formations that are exposed in central and S.-central Indiana. Clastics were supplied by the Pennsylvanian formations that crop out in the lower Wabash Valley. Chert was contributed by one or more formations in each of the Paleozoic systems exposed in the Wabash Valley. The igneous and metamorphic rocks, whose ultimate source was the Canadian Shield, were supplied by the gravel fraction of Wisconsin till deposits. This study provides an illustrative example of the concept of progressive dilution.--Auth.

3-1986. Hamblin, William Kenneth, and William J. Horner. **SOURCES OF THE KEWEENAWAN CONGLOMERATES OF NORTHERN MICHIGAN: Jour. Geology, v. 69, no. 2, p. 204-211, 3 figs., 2 tables, March 1961, 20 refs.**

A statistical study of the orientation of current structures in the sediments of the Portage Lake lava series and Copper Harbor conglomerate was made to determine the sources of the Keweenawan conglomerates of northern Michigan.

These data clearly indicate that the major paleogeographic features in the Lake Superior region during Keweenawan time were an elongate basin, trending NE. between Isle Royale and the Keweenaw Peninsula, with bordering highlands to the W. and SE. The principal source area for the conglomerates on the Keweenaw Peninsula was probably not more than 10 mi. SE. of the present outcrop belt, with the general area of the Huron Mountains being an important center of dispersal. The conglomerates on Isle Royale were derived from nearby highlands in Minnesota and Canada.--Auth.

3-1987. Cooley, Maurice E. **ANALYSIS OF GRAVEL IN GLEN-SAN JUAN CANYON REGION, UTAH AND ARIZONA: Arizona Geol. Soc., Digest, v. 3, p. 19-30, fig., table, 1960, 7 refs.**

An analysis of 141 samples from gravel deposits which occur in Glen and San Juan canyons and the surrounding regions was made 1) to determine the composition of gravels deposited in the canyon area by the Colorado and San Juan rivers; 2) to recognize individual types and assemblages; 3) to compare pebble assemblages of all units sampled for possible correlation; 4) to check the amount of re-working of older gravels; and 5) to obtain information concerning the distribution and general source directions of the pebble assemblages and individual types.--From auth. introd.

3-1988. Gulbrandsen, Robert A. **A METHOD OF X-RAY ANALYSIS FOR DETERMINING THE RATIO OF CALCITE TO DOLOMITE IN MINERAL MIXTURES: U.S. Geol. Survey, Bull. 1111-D, p. 147-152, graph, 5 tables, 1960, 5 refs.**

The use of X-ray methods for determining the proportion of calcite to dolomite in carbonate rocks is apparently not common. Accordingly, an experiment was designed to test the usefulness of X-ray diffraction intensities (peak heights) of calcite and dolomite as a means of estimating the percentage ratio of these minerals in carbonate rocks of the Meade Peak phosphatic shale member of Coal Canyon, Wyoming.

X-ray analyses were made of 16 prepared mineral mixtures of a known composition that was similar to that of the carbonate rocks of the phosphatic shale member. The analyses indicate that the differences between the peak heights of calcite and dolomite are due to differences in amounts of calcite and dolomite, and that the ratios of the peak heights are useful as a measure of the ratios of calcite to dolomite.--Auth.

3-1989. Bisque, Ramon E. **ANALYSIS OF CARBONATE ROCKS FOR CALCIUM, MAGNESIUM, IRON, AND ALUMINUM WITH EDTA: Jour. Sed. Petrology, v. 31, no. 1, p. 113-122, fig., table, March 1961, 12 refs.**

A procedure for the rapid volumetric analysis of carbonate rocks for Ca, Mg, Fe, and Al is presented in a form to aid the inexperienced analyst. The 4 elements are determined with the use of EDTA (ethylenediaminetetracetic acid), an organic chelating agent. Instructions for the gravimetric determination of silica are also included.

Literature concerning the determination of Ca, Mg, and Fe with EDTA has appeared in the chemical journals, and the adaptation of EDTA techniques to the determination of Al has also been discussed. The inexperienced analyst might find it difficult, however, to trace and apply the information to the problem of analyzing carbonate rocks for the 4 elements mentioned. It is felt that this report will enable a person with a minimum of analytical training to perform analyses rapidly and with accuracy sufficient for most commercial and investigative needs. A list of the chemicals and equipment required is included, and sample calculations are given. Knowledge of only the most fundamental laboratory operations such as "dilute to volume," "titrate," "transfer quantitatively," and "pipette," is assumed.--Auth.

3-1990. Graf, Donald L., and others. **A PRELIMINARY REPORT ON MAGNESIUM CARBONATE FORMATION IN GLACIAL LAKE BONNEVILLE: Jour. Geology, v. 69, no. 2, p. 219-223, 2 figs., March 1961, 23 refs.**

A thin bed of unconsolidated dolomite occurs about a foot below the surface of the Great Salt Lake desert west of Knolls, Utah. A C^{14} date correlates with the onset of a drier climate and the desiccation of Lake Bonneville to the present Great Salt Lake. Shoreward, the dolomite zone is represented by a mixture of aragonite and a magnesitelike material, with an enlarged unit cell. Chemical-enrichment techniques have been utilized in obtaining minor-element abundance data.--Auth.

3-1991. Pye, Willard D. **TECHNIQUES OF POROSITY, PERMEABILITY AND INSOLUBLE RESIDUE ANALYSIS OF CARBONATES AND THEIR ECONOMIC SIGNIFICANCE, AS BASED ON A STUDY OF**

THE ORDOVICIAN AND SILURIAN SECTION OF THE WILLISTON BASIN: Arizona Geol. Soc., Digest, v. 3, p. 103-107, 1960, 5 refs.

Analysis techniques were sought to find those most applicable in problems of 1) zoning of a predominantly carbonate section, 2) correlating sections, 3) determining sources of sediments and conditions of deposition, and 4) determining character and patterns of secondary porosity and permeability developed within a carbonate section of ground-water solution. The porosity pattern, the tortuosity of the channelways, the orientation of the minerals lining the pore walls, and the mineralogy of the pore walls in contact with formation fluids and gases, are significant in connection with the problem of fluid migration and their recovery. The Ordovician and Silurian section in the eastern part of the Williston basin of North Dakota and Manitoba was selected for purpose of the study. Sand and chert residues appear to be usable for correlation criteria. Secondary porosity is generally most important.--M. Russell.

3-1992. Arnal, Robert E. LIMNOLOGY, SEDIMENTATION, AND MICROORGANISMS OF THE SALTON SEA, CALIFORNIA: Geol. Soc. America, Bull., v. 72, no. 3, p. 427-478, 27 figs., 11 tables, March 1961, 40 refs.

The Salton Sea, originally a fresh-water lake formed by the flood of the Colorado River in 1905, is located in the center of the Colorado Desert of California. By 1929, the water of the lake had become almost as saline as ocean water because of intense evaporation and solution of salts present on the floor of the basin before the flood. In recent years, in spite of the high rate of evaporation, excessive runoff from irrigation water has maintained and even raised the level of the lake.

Evaluation of the water budget has made it possible to anticipate future changes in the chemical composition of the water - i. e., an increase in the amount of sulfates is predicted for the future. Measurements with a current cross and studies of salinity distribution indicate a counter-clockwise current pattern in the Salton Sea.

Sands, silts, and clays are deposited in that order from the shoreline to the center of the lake. The water content, amount of calcium carbonate, and textural characteristics indicate that most of the sediments of the Salton Sea were derived from the suspended load of the Colorado River, whereas the mineralogical study suggests that some of the sediments have a local origin. Two entirely different methods of computing the rate of sedimentation and of calculating the amount of calcium carbonate in the sediments give results of the same order of magnitude. The large amount of calcium carbonate is partly due to precipitation and partly to transportation by Colorado River water.

Forminifera are the most abundant microorganisms in the lake. Several ecological factors influence their distribution; among these factors, chlorinity and temperature are not important, depth may be important by its effect on other factors, but the variation in the pH of the sediments is significant. The living foraminiferal assemblage is due to accidental introduction, but the natural effect of environmental conditions has resulted in the creation of a dwarf fauna and many malformed individuals. In contrast to conditions in the ocean, abundance of species decreases offshore; however, as in the ocean, the number of living Foraminifera increases greatly after a bloom of phytoplankton. The average productivity of the Salton Sea is greater than that of the oceans.

Conclusions derived from this study were applied to sediments deposited in the same basin during the past and made it possible to suggest a late Pliocene or early Pleistocene age for the Borrego formation and a Pleistocene age for the Brawley formation.--Auth.

3-1993. Cadigan, Robert A. GEOLOGIC INTERPRETATION OF GRAIN-SIZE DISTRIBUTION MEASUREMENTS OF COLORADO PLATEAU SEDIMENTARY ROCKS: Jour. Geology, v. 69, no. 2, p. 121-144, 11 figs., 6 tables, March 1961, 20 refs.

A petrographic study was made of sedimentary rocks of Permian, Triassic, and Jurassic age on the Colorado Plateau. The source areas of the detrital sediments were positive areas of igneous, metamorphic, sedimentary, and volcanic terranes. Most of the sediments were deposited on a flat, slowly subsiding depositional plain; shallow-water embayments alternated with eolian or alluvial environments.

It was found that mean grain size can be translated as average grain size and is related to tectonic uplift, gradient, and energy level. Standard deviation can be translated as average sorting and related to tectonic subsidence, rate of deposition, and amount of reworking. Skewness and kurtosis can be translated as measures of internal sorting contrasts and related to amount of reworking and accumulated energy.

Differences in statistical measures of the grain-size distributions of samples from vertical sequences of sediments are interpreted in terms of minor and major tectonic changes in the source areas and areas of deposition.--Auth.

3-1994. Peckham, Alan E. HEAVY MINERALS OF THE MIOCENE HARRISON FORMATION IN NORTHWESTERN NEBRASKA: Jour. Sed. Petrology, v. 31, no. 1, p. 52-62, 2 figs., 3 tables, March 1961, 23 refs.

The heavy minerals identified in this study indicate that the sediments of the Harrison formation were derived from mixed sources and from reworked sediments originally deposited W. of the study area. Easily weathered unstable minerals are rare or absent. No significant heavy mineral zonations of the Harrison formation are evident from this study.

Daemonelix forms were found in the lower portion of the Harrison formation at its type locality where they have heretofore been recognized only in the upper portion of the formation.

The use of bromoform facilitates heavy mineral separation because it is easily frozen, and heavy mineral concentrations can be readily trapped by freezing the lower end of a test tube in which the separation has been made. The floating light minerals and unfrozen bromoform can be decanted, leaving a clean heavy mineral concentrate.--Auth.

3-1995. Wiesnet, D. R. COMPOSITION, GRAIN SIZE, ROUNDNESS, AND SPHERICITY OF THE POTSDAM SANDSTONE (CAMBRIAN) IN NORTHEASTERN NEW YORK: Jour. Sed. Petrology, v. 31, no. 1, p. 5-14, 9 figs., 3 tables, March 1961, 15 refs.

The Potsdam sandstone of Late Cambrian age crops out along the N., E., and SE. borders of the Adirondack Mountains in northeastern New York

State. It has generally been described as an orthoquartzite. In the Mooers area, however, the Potsdam is mainly a subarkose or arkose.

Detailed analysis of 10 thin sections of the Potsdam sandstone from the Mooers Quadrangle provide data for grain-count composition, median grain size, cumulative size curves for individual samples, mean grain size, coefficient of sorting, roundness, and sphericity. The examination of 25 additional thin sections provided data for a lithofacies map.

In the Mooers area, the Potsdam can be distinguished from the sandstone in the overlying Theresa dolomite, which, unlike the Potsdam, contains no zircon, very little feldspar, and very well rounded quartz grains. Mean grain roundness in the Potsdam ranges from 0.4 to 0.5; sphericity ranges from 0.73 to 0.79. The relation of roundness to sphericity is similar to that reported in other published studies. The median size decreases and sphericity increases to the N., away from outcropping Precambrian rocks. Sorting is best and median grain size smallest where the beds dip least, suggesting that the dip is probably primary. Sedimentary analysis by thin-section techniques gives abundant, fairly reliable quantitative data for sedimentary studies.--Auth.

3-1996. Gulbrandsen, Robert A. PETROLOGY OF THE MEADE PEAK PHOSPHATIC SHALE MEMBER OF THE PHOSPHORIA FORMATION AT COAL CANYON, WYOMING: U.S. Geol. Survey, Bull. 1111-C, p. 71-146, 11 figs., 6 pls. (2 in pocket), 14 tables, 1960, 131 refs.

The member is 143 ft. thick and consists of dark thin-bedded phosphorites and carbonate and quartz-silicate rocks. The average chemical composition, in percent, of the member is: SiO_2, 26.5; TiO_2, 0.2; Al_2O_3, 4.5; Fe_2O_3, 1.8; MgO, 4.5; CaO, 27.0; Na_2O, 0.9; K_2O, 1.6; P_2O_5, 10.6; CO_2, 13.8; F, 1.1; SO_3, 2.0; H_2O, 0.9; and carbonaceous material, 4.8. The member contains unusually high amounts of P and F. The average Ca-Mg ratio for the member is 6, but it ranges from 88 for the average phosphorite to 2.9 for the average carbonate rock.

Important minor constituents that occur in the rocks in significant amounts are V, Se, and U. In 3.5 ft. of carbonaceous quartz-silicate rock, the vanadiferous zone, V averages 0.7% V_2O_5 and Se ranges from 90 to 150 p.p.m. The U content of the whole member ranges from 0.0005 to 0.034% and averages 0.004%.

Carbonate-fluorapatite makes up 28% of the member, dolomite 21% and calcite 8%. These 3 minerals, chemically related compounds that have Ca and carbonate ions in common, occur in 3 principal associations: carbonate-fluorapatite alone, dolomite and carbonate-fluorapatite mixtures, and dolomite and calcite mixtures. The origin of these associations is considered on the basis of phase relations. --Auth.

3-1997. Ericson, David B., and others. ATLANTIC DEEP-SEA SEDIMENT CORES: Geol. Soc. America, Bull., v. 72, no. 2, p. 193-285, 50 figs, 3 pls., 6 tables, Feb. 1961, 81 refs.

Studies of lithology, particle-size distributions, and micropaleontology and chemical analyses of 221 Atlantic and Caribbean deep-sea cores lead to new conceptions of processes of sedimentation, rates of sediment accumulation, Pleistocene chronology and pre-Pleistocene history of the Atlantic basin.

Anomalous layers of sand, silt, and lutite occur widely in the deep basins of the Atlantic. Evidence for deposition of these layers by turbidity currents is as follows: 1) the layers occur in submarine canyons, in deltalike features at the terminal ends of canyons, in basins and depressions, never on isolated rises; 2) they are interbedded with late Pleistocene sediments of abyssal facies; 3) they are well-sorted and commonly graded; and 4) they commonly contain organic remains of shallow-water origin.

Late Pleistocene slumping of compacted Neogene sediments along the banks of the Hudson submarine canyon at depths exceeding 3,000 m. indicates deepening of the canyon by erosion by turbidity currents.

Variations in the planktonic Foraminifera in 108 of the cores and extrapolation of rates of sediment accumulation determined by 37 radiocarbon dates in 10 cores show that the last period of climate comparable with the present ended about 60,000 years ago.

A faunal change indicating climatic amelioration, probably corresponding to the beginning of postglacial time, occurred about 11,000 years ago. Cross-correlations by micropaleontological methods establish the continuity of the climatic record deduced from the planktonic Foraminifera. Study of variation in the planktonic Foraminifera leads to a different Pleistocene chronology from that proposed by Emiliani.

Cross-correlations of faunal zones and radiocarbon dates show that rates of continuous sediment accumulation, as opposed to turbidity-current deposition, range from 0.5 cm. to 274.4 cm. in 1,000 years, depending upon bottom configuration. Cross-correlations by means of changes in coiling direction of planktonic Foraminifera give relative rates of sediment accumulation beyond the range of the radiocarbon method of dating.

Forty-one of the cores contain pre-Pleistocene sediments. The oldest sediment is Upper Cretaceous. Foraminifera and discoasters indicate the ages. Absence of sediment older than Late Cretaceous and thickness, 800-1,000 m., of sediment in the Atlantic basin as determined by seismic methods suggest that a large-scale reorganization of the Atlantic basin took place in the Mesozoic.--Auth.

11. GEOHYDROLOGY

See also: Geomorphology 3-1774; Geochemistry 3-1903, 3-1906.

3-1998. Stallman, Robert W. FROM GEOLOGIC DATA TO AQUIFER ANALOG MODELS: GeoTimes, v. 5, no. 7, p. 8-11, 37, 5 illus., Apr. 1961.

Analog-computer equipment developed by the U. S. Geological Survey and the role of such equipment in ground-water studies is described. Electric analogs are versatile, simple, cheap means of computing solutions to areal problems of nonsteady liquid flow through porous media. The electric model of an aquifer flow system is an array of electrical components selected and placed in a manner such that the electrical network functions as a scaled version of the aquifer system. Analysis of an aquifer flow system by electric analog permits the inclusion of more known variables than can be processed practically by other mathematical techniques, and permits the analytical result to be expressed directly in useful terms.--M. Russell.

3-1999. Farvolden, R. N. A FARM WATER SUPPLY FROM QUICKSAND: Research Council Alberta, Prelim. Rept. 61-3, 12 p., 3 illus., 1961.

At many locations in Alberta fine-grained, well sorted, unconsolidated sand termed quicksand is encountered when drilling for water. Where such sand is saturated it tends to heave into the well bore; in the past it was generally considered impossible to complete a satisfactory well in this material. Experiments carried out in the Edmonton area indicate that either gravel envelope wells or screened wells may be successfully completed in quicksand.

The similarity in the grain size and sorting of quicksand samples collected at widely separated localities in the province indicates that the same methods should be applicable wherever quicksand is encountered in Alberta.--W. A. Meneley.

3-2000. Price, Charles E. ARTIFICIAL RECHARGE THROUGH A WELL TAPPING BASALT AQUIFERS, WALLA WALLA AREA, WASHINGTON: U.S. Geol. Survey, Water-Supply Paper 1594-A, p. A1-A33, 4 figs., 8 tables, 1961, 8 refs.

Declining water levels in part of the Columbia lava plateau, owing to pumping, have caused concern for several years. Therefore, the U.S. Geological Survey in cooperation with the state of Washington Dept. of Conservation carried out an experiment to determine the feasibility of artificial recharge to halt the decline of water levels in part of the Walla Walla basin, Washington. During the experiment 71.3 acre-ft. (23 million gallons) of surface water was injected into basalt through Walla Walla city well 3 at rates ranging from 630 to 670 gallons per minute. The chemical and bacteriological quality of the injected water was excellent, and the water contained only 2 parts per million of suspended sediment. The injected water probably was nearly saturated with air when it entered the top of the well and may have entrained some additional air as it fell into the well.

The water injection caused a rise of the water level and hence increased the amount of ground water in storage in the local area. However, the subsequent yield and specific capacity of the well were impaired. The data obtained during the tests suggest that hydraulic boundaries limit the lateral movement of water. The tests indicate also that the coefficient of transmissibility of the basalt is about 400,000 gallons per day per foot and that the coefficient of storage is about 0.0002.--Auth.

3-2001. Walker, Theodore R. GROUND-WATER CONTAMINATION IN THE ROCKY MOUNTAIN ARSENAL AREA, DENVER, COLORADO: Geol. Soc. America, Bull., v. 72, no. 3, p. 489-494, 2 maps, March 1961, 2 refs.

Improper waste-disposal practices at the Rocky Mountain Arsenal have seriously damaged the free ground-water aquifer throughout an area of approximately 6 1/2 sq. mi. Contaminants include chlorates and 2,4-D-type compounds, both of which are effective herbicides. Contaminated ground water within the affected area is toxic to agricultural crops and unpotable for humans. Corrective measures have been taken to halt further contamination, but the area of toxicity is expanding owing to migration of the body of ground water already contaminated.--Auth.

3-2002. U.S. Geological Survey. GROUND-WATER LEVELS IN THE UNITED STATES, 1956-57. NORTHEASTERN STATES: Its: Water-Supply Paper 1537, 144 p., 13 maps, tables, 1960, refs.

This report covers Connecticut, Delaware, Indiana, Maine, Massachusetts, Michigan, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, and Rhode Island. Water-level data from a basic network of observation wells is published by county for each state. The minimum basic network provides observation wells so located that the most significant data are obtained from the fewest wells in the most important aquifers. Water-level measurements are given in feet with reference to either mean sea level or land-surface datum. The levels are reported to as many significant figures as can be justified by the local conditions and the end use of the information.--A.C. Sangree.

3-2003. Cushing, Elliott M., and others. PROGRESS REPORT ON STUDY OF THE GEOHYDROLOGY OF THE MISSISSIPPI EMBAYMENT AREA: U.S. Geol. Survey, Repts., Open-File Ser., 23 p., 9 figs. incl. maps, 3 tables, March 1960, 3 refs.

The Mississippi embayment investigation covers about 90,000 sq. mi. of the Gulf Coastal Plain. From its apex in southern Illinois the area fans out southward and includes parts of Alabama, Arkansas, Illinois, Kentucky, Louisiana, Mississippi, Missouri, Tennessee, and Texas.

For some millions of years in the past this area was an embayment occupied by an arm of the sea, in which as much as several thousand feet of sediments were deposited. Deposits of sand now form vast regional water-bearing units, some of which are highly productive and extend across county and state boundaries and also topographic boundaries to connect drainage basins which on the land surface appear to be independent units. This apparently water-rich area receives 45 to 50 in. of precipitation in average years and is crossed by several large rivers.

Most of the water-resources investigations in the area have been made in cooperation with state, county, and municipal agencies and have been restricted to local areas where the need for information was most urgent. This comprehensive study of the water resources of the area was begun in Aug. 1957. During the 1959 fiscal year the ground-water phase of the study was directed toward defining the regional structure and stratigraphy of the area. The surface-water work was directed toward a low-flow analysis of the area. The quality-of-water work included the evaluation of the available ground-water analyses with respect to completeness, accuracy, and reliability, and the preparation of an embayment pattern for each complete analysis. Patterns have been prepared for the Arkansas, Illinois, Louisiana, Mississippi, and Missouri analyses.

Work plans for the 1960 fiscal year include continued analysis of the subsurface information, preparation of a comprehensive report on the subsurface geology, continued operation of the partial-record stations, completion of the processing of gaging-station records to obtain low-flow and flow-duration information, initiation of the low-flow analysis of a part of the area, continued evaluation of the chemical analyses and preparation of embayment patterns, and initiation of a study to relate the chemical quality of the water to its geographic and geologic environment.--From auth.

3-2004. Scott, John C. GROUND-WATER RESOURCES OF AUTAUGA COUNTY, ALABAMA; A

RECONNAISSANCE REPORT: Alabama, Geol. Survey, Inf. Ser. 21, 92 p., 8 figs., 4 pls. (in pocket), 4 tables, 1960, 13 refs.

Autauga County, in S.-central Alabama, has an area of 599 sq. mi. The county is in the northern part of the Coastal Plain province and is divided physiographically into the Central Pine Belt and the flood plain of the Alabama River. The terrain is hilly, ranging in altitude from about 100 ft. above sea level in the basin of the Alabama River in the S. to almost 700 ft. in the N.

The county is underlain by sedimentary deposits of Late Cretaceous age, which rest on a basement complex of pre-Cretaceous metamorphic and igneous rocks. The Late Cretaceous deposits consist of the Coker and the Gordo formations of the Tuscaloosa group, the Eutaw formation, and the Mooreville chalk of the Selma group. Terrace and alluvial deposits of Quaternary age overlie the Cretaceous rocks in and adjacent to the flood plains of the Alabama River and larger tributaries.

The chief sources of ground water are aquifers in the Coker, Gordo, and Eutaw formations. Water for domestic and stock use also is obtained from the terrace and alluvial deposits. Large quantities of ground water are used in the southern part of the county, where flowing wells are common, but only small quantities are used in other parts. Yields of 300 g.p.m. (gallons per minute) or more can be obtained from wells in the Coker and Gordo formations. Sands in the Gordo and Eutaw formations tapped by a well near Autaugaville, based on a 24-hr. pumping test, have a coefficient of transmissibility of about 18,000 g.p.d. (gallons per day) per ft.

Ground water in Autauga County is generally soft and contains a relatively small amount of fluoride and sulfate. In some parts of the county the water contains an objectionable amount of Fe but is otherwise suitable for most uses. Water in the Eutaw formation in the extreme SW. corner of the county contains as much as 592 p.p.m. (parts per million) chloride.--Auth.

3-2005. Harris, Hobart B., and others. INTERIM REPORT ON GROUND-WATER STUDY IN COLBERT COUNTY, ALABAMA: Alabama, Geol. Survey, Inf. Ser. 20, 59 p., 4 figs., map (in pocket), 2 tables, 1960, 2 refs.

Colbert County, in northwestern Alabama, comprises an area of 618 sq. mi. The area is underlain by beds of limestone, sandstone, shale, and chert of Mississippian age. Moderate to large supplies of ground water are obtainable from cavities and other openings in the limestones. Most of these openings occur at depths of 100 ft. or less. Smaller amounts of ground water can be obtained from sand and gravel of the Tuscaloosa group and from the weathered material overlying bedrock. The ground water ranges in quality from soft to hard, and is moderately low in dissolved solids, sulfate, and chloride.--Auth. summ. & concl.

3-2006. Hollander, J.T. GEOLOGY AND AQUIFER CHARACTERISTICS OF THE INNER-VALLEY ALLUVIUM IN THE SAFFORD VALLEY, ARIZONA: Arizona Geol. Soc., Digest, v. 3, p. 133-135, 1960, 2 refs.

Recent fill in the inner valleys is fluviatile, ranges from 20 to 110 ft. in thickness and consists of unconsolidated silt, sand, gravel, cobbles, and boulders. Ground water occurs at shallow depths in most wells, about 25 ft. below land surface. In many wells water is encountered in more than one zone at depth. The aquifers are sand and gravel underlain by lacustrine-type clay. Water is predominantly unconfined. Recharge is by natural means from the Gila River and precipitation over the valley floor and by artificial means from irrigation canals and cultivated lands over which irrigation water is spread.--M. Russell.

3-2007. Akers, J.P. GROUND WATER IN THE RED LAKE AREA, NAVAJO INDIAN RESERVATION, ARIZONA AND NEW MEXICO: Arizona Geol. Soc., Digest, v. 3, p. 41-42, 1960.

The Navajo Tribal Council requested the U. S. Geological Survey to conduct a study of the ground-water resources of the Red Lake area to determine if 1,000,000 g.p.d. (gallons per day) of water was available for the operation of a proposed sawmill. The Red Lake area lies in a synclinal valley between the Defiance Plateau and the Chuska Mountains. Several sites were selected for drilling in alluvium along Tohdildonih Wash, and in volcanic material in Buell Park; one site was selected for a deep test in consolidated rock near the southwestern bank of Red Lake. Seven production wells completed in the Red Lake area are capable of supplying the required minimum. The combined yield is 1,500,000 g.p.d., and, should the need arise, additional water can be developed in Buell Park.--From auth. introd. & concl.

3-2008. Lichtler, William F. GEOLOGY AND GROUND-WATER RESOURCES OF MARTIN COUNTY, FLORIDA: Florida, Geol. Survey, Rept. Inv. no. 23, 149 p., 26 figs. incl. maps, graphs, 8 tables, 1960, 33 refs.

Martin County, in the southeastern part of peninsular Florida, comprises an area of about 560 sq. mi., in the Atlantic Coastal Plain physiographic province. Land-surface altitudes range from mean sea level to 86 ft. above. The slope of the land surface is gentle except in the sandhill regions in the eastern part of the county.

Formations penetrated by wells in Martin County include the Avon Park limestone and the Ocala group of Eocene age; the Suwannee limestone of Oligocene age; the Hawthorn formation, and possibly the Tampa and Tamiami formations, of Miocene age; the Caloosahatchee marl of Pliocene age; and the Anastasia formation and the Pamlico sand, of Pleistocene age.

There are 2 major aquifers in Martin County: 1) the shallow (nonartesian) aquifer, 15 to 150 ft. below the land surface, and 2) the Floridan (artesian) aquifer, 600 to 1,500 ft. below the land surface. The Anastasia formation is probably the principal source of ground water in the shallow aquifer. Permeable parts of the Avon Park limestone and the Ocala group compose the principal producing zones of the Floridan aquifer. The 2 aquifers are separated by a thick section of sand and clay of low permeability.

At most places along the Atlantic Coastal ridge open-end wells 60 to 130 [ft.] deep can be constructed in thin rock layers or shell beds of the shallow aquifer. Some wells are screened at depths ranging from 15 to 60 ft. In the eastern part of the eastern flatlands, the geologic and hydrologic conditions are similar to those of the Atlantic Coastal ridge. The rock layers wedge out in the central part of the county, and it is difficult to obtain large quantities of potable water at most places in the western part of the county. In the Indiantown area, a shell bed at a depth of 95 ft. is the principal source of large ground-water supplies.

Most of the recharge to the shallow aquifer is supplied by rainfall within Martin County. Water from the shallow aquifer is discharged by outflow into streams, canals, and other surface-water bodies, by evapotranspiration, and by pumping. The principal recharge to the artesian aquifer in central and southern Florida is from rainfall in the topographically high areas centered in Polk and Pasco counties. Water is discharged from the Floridan aquifer in Martin County mostly through flowing wells.

Yields from wells in the Floridan aquifer range from about 10 to 750 g.p.m. (gallons per minute). Yields from wells in the shallow aquifer range from a few gallons per minute to more than 500 g.p.m. The coefficients of transmissibility and storage of the shallow aquifer differ at different locations and depths, thus indicating that the composition of the aquifer is not uniform. Transmissibility coefficients obtained from test data range from 16,000 to 83,000 g.p.d. (gallons per day) per foot, and storage coefficients range from 0.0001 to 0.0065.

Chemical analyses of 56 water samples from Martin County indicate that the water from the shallow aquifer, although hard, is generally of good quality. The water from the artesian aquifer is highly mineralized. Temperatures of water range from 70° to 82°F. in the shallow aquifer and range from 75° to 91°F. in the artesian aquifer.

Recent salt-water encroachment in the shallow aquifer has occurred on Hutchinson Island, Jupiter Island, and Sewall Point and in some coastal areas on the mainland. In some areas of western Martin County the lower part of the shallow aquifer contains salt water that entered the aquifer when the present land surface was under the sea, during the Pleistocene epoch. Sea water that entered the Floridan aquifer during that time is responsible also for much of the high mineral content of the artesian water.

Most of the water used for public, domestic, and industrial supplies and much of the irrigation and stock water is obtained from the shallow aquifer. The water from the artesian aquifer is used for irrigation, stock watering, and swimming pools.--Auth.

3-2009. Leve, Gilbert W. **RECONNAISSANCE OF THE GROUND-WATER RESOURCES OF THE FERNANDINA AREA, NASSAU COUNTY, FLORIDA: Florida, Geol. Survey, Inf. Circ. no. 28, 24 p., 7 figs. incl. maps, graphs, 2 tables, 1961, 3 refs.**

This report describes an area approximately 8 1/2 mi. long and 6 mi. wide, adjacent to the Atlantic Ocean in northeastern Florida. Sand and alluvium of Pleistocene and Recent age are exposed at the surface. They are immediately underlain by undifferentiated deposits of marl, sand, and shell of undetermined age. These, in turn, are underlain by the Hawthorn formation of middle Miocene age which consists predominantly of clay beds. The Hawthorn formation is underlain by limestones of Eocene age whose top was found to be 550 ft. below land surface in one well.

The limestones of Eocene age contain water under artesian pressure and are the principal source of water in the area. The artesian aquifer is recharged to the N. and W. of the area where the limestones crop out or are hydrologically connected to bodies of surface water.

Water is discharged from the aquifer in the Fernandina area by municipal and industrial wells. This discharge has created a depression in the piezometric surface in the Fernandina area. Since 1946, there has been a decline in the piezometric surface of about 10 to more than 20 ft., and the area in which the altitude of the piezometric surface is at or below mean sea level has approximately tripled. Hydrographs of water levels show that in the area of discharge, the artesian pressure has declined more than 50 ft. since 1939.

The chloride content of water in 1959 ranged from 26 to 41 p.p.m. (parts per million) from wells less than 1,400 ft. deep and from 50 to 1,060 p.p.m. from wells more than 1,400 ft. deep. Recently there has been a general increase in the chloride content of water from wells tapping the artesian aquifer. This increase averaged less than 10 p.p.m. since 1940 in wells less than 1,400 ft. deep, and from 20 to 640 p.p.m. since 1952 in wells more than 1,400 ft. deep.

Possible sources of salt-water contamination may be salt zones in the lower part of the aquifer below the fresh-water zone or thin zones of mineralized water within the fresh-water zone. Most water samples collected did not indicate sufficient saline content to endanger municipal and industrial supplies. However, as more water is withdrawn from the artesian aquifer and wells are drilled deeper into the lower part of the aquifer, it is possible that increasing amounts of saline water may move into the fresh-water zones and make them unsuitable for domestic and industrial use.--Auth.

3-2010. Mundorff, Maurice John, and others. **GROUND WATER FOR IRRIGATION IN THE SNAKE RIVER BASIN IN IDAHO: U.S. Geol. Survey, Repts., Open-File Ser., 201 p., 60 figs. incl. maps, secs., diags., graphs, 14 tables, 1960, 59 refs.**

The Snake River basin, in southern Idaho, upstream from the mouth of the Powder River in Oregon, includes more than 50% of the land area and 65% of the total population of the state. More than 2.5 million acres of land is irrigated. The chief tasks in development of the ground-water resources include not only locating and evaluating ground-water supplies but also the planning necessary to bring the water to the land.

The Snake River basin may be considered as consisting of 3 types of terrain with respect to water. The first type consists of mountains and plateaus, where precipitation may be more than 50 in. annually. This type of terrain has an excess of water above that which is consumed within the area, resulting in surface and underground runoff from the area.

The second type of terrain consists of soil-mantled terraces, benches, and plains, where the moderate precipitation (generally less than 10 in. annually) is nearly all consumed by evaporation and the native vegetation and where the water table is far enough below the surface that vegetation cannot reach it. This type of terrain contributes very little to the regional water supply nor does it withdraw any water from it.

The third type of terrain includes plains, basins, and valleys, where the water table generally is near the surface, and consumption of water by vegetation and loss by evaporation exceeds the amount of water contributed by precipitation. Irrigated tracts are included in this terrain type. In these areas the regional water supply is diminished.

A principal feature of the Snake River basin is the gently rolling Snake River plain, which extends in a broad arc, concave to the N., from eastern Idaho near Yellowstone Park into Oregon. The plain is from 30 to 75 mi. wide. It is bordered on both its N. and S. flanks by high plateaus and mountain ranges. The Snake River flows along the southern (convex) margin of the plain. The Snake River serves as the trunk drainageway for all water moving out of the basin and receives all surface- and ground-water discharge from the Snake River plain and tributary valleys.

The water regimen in the Snake River basin is greatly influenced by the geology. The rocks forming the mountains are largely consolidated rocks of low permeability. However, a fairly deep and porous subsoil has formed on them by decay and disintegration of the parent rock. Broad intermontane valleys and basins are partly filled with alluvial sand and gravel. The subsoil and alluvial materials are utilized very little as a source of water supply but are important as seasonal ground-water reservoirs, storing water during periods of high rainfall and snowmelt. Discharge from these reservoirs maintains streamflow during periods of no surface runoff. Because these aquifers are fairly thin, they drain rapidly and are considerably depleted at the end of each dry cycle.

The plain and plateau areas and tributary valleys, are underlain chiefly by rocks of high permeability and porosity. These rocks, mostly basaltic lava flows and alluvial materials, constitute a reservoir which fluctuates only slightly from season to season. Large amounts of water are withdrawn from them for irrigation and other uses, and discharge from the Snake Plain aquifer is an important element of the total flow of the Snake River downstream from Hagerman Valley.

The ultimate source of ground water in the basin is precipitation on the basin. Evaluation of the water yield of the various basins tributary to the Snake River plain was done by establishing a relation between average precipitation on selected basins and the water yield from the basin. In establishing this relation, only those basins could be used where the total water yield of the basin was known with a fair degree of accuracy.

For convenience in describing the ground water in various places, the Snake River basin was divided into ground-water subareas, 19 of which are described.

The series of basalt flows and intercalated pyroclastic and sedimentary materials that underlie the Snake River plain E. of Bliss is defined as the Snake Plain aquifer. This aquifer is one of the world's outstanding water-bearing formations. A large number of pumping tests and many specific-capacity data indicate that the coefficient of transmissibility of the upper part of the aquifer generally ranges from 1 to 10 m.g.d. (million gallons per day) per ft. As most of the wells only penetrate a part of the aquifer, the coefficient of transmissibility of the entire aquifer is greater. Data from pumping tests and laboratory studies indicate that the average coefficient of storage probably is at least 5% and may approach 10%.

Recharge to the Snake Plain aquifer is from: 1) precipitation directly upon the plain, 2) percolation of irrigation water, 3) seepage from streams entering or crossing the plain, and 4) underflow from tributary basins. The water table beneath the Snake River plain is in dynamic balance between recharge and discharge.

The Snake Plain aquifer provides an excellent opportunity for artifical-recharging operations. Chief sources of water for recharging the Snake Plain aquifer are the Snake River and Henrys Fork. With present utilization of surface water, 700,000 acre-ft. or more of water might be available in about half the years. Little or no water would be available in most of the other years. Based on past records, there would be periods of 8 to 10 years when no water would be available for recharging and periods of about equal length when a large amount would be available each year.

Several areas on the plain appear to be particularly favorable for recharging. One area is between the Egin Bench and Roberts. A second is SW. of Idaho Falls, and a third is N. and NW. of American Falls Reservoir.--From auth. summ.

3-2011. Sinclair, William C. RECONNAISSANCE OF THE GROUND-WATER RESOURCES OF DELTA COUNTY, MICHIGAN: Michigan, Geol. Survey Div., Prog. Rept. no. 24, 93 p., 12 figs., 6 tables, 1960, 22 refs.

Delta County is on the N. shore of Lake Michigan in the S.-central part of Michigan's Northern Peninsula. The county is in the northwestern part of the Michigan basin, where Paleozoic rocks of Ordovician and Silurian age form the bedrock surface. During the Pleistocene epoch, a discontinuous mantle of glacial drift of varying thickness was deposited on the bedrock surface.

Most of the ground-water supplies of Delta County are derived from various bedrock aquifers. Several deep and relatively large-capacity wells tap the sandstones of the Munising [Cambrian] and Au Train [Ordovician] formations in the western part of the county. About half the wells in the county, however, obtain small to moderate supplies at shallow depth from limestone of the Black River and Trenton formations [Ordovician]. Shale of the Collingwood formation [Ordovician] and the basal members of the Richmond group [Ordovician] yield small amounts of highly saline water. Limestone and dolomite of the Richmond group locally are a source of fresh ground water on the Stonington Peninsula and northeastern part of the county. The Cataract formation [Silurian] yields small to moderate supplies of water to wells in the southeastern part of the county, but the water is very hard and has a high sulfate content. On the Garden Peninsula, the Burnt Bluff and Manistique formations [Silurian] are sources of hard to very hard water, which is otherwise of good chemical quality. In many parts of the county, the glacial drift is a source of small supplies. These deposits have considerable potential as a source of moderate to large supplies in the presently undeveloped northeastern part of the county.

Although adequate quantities of ground water are available throughout Delta County, adequate supplies of good quality may be difficult to obtain in various areas. Fresh-water aquifers tapped at depth must be protected from vertical leakage of saline water through uncased wells penetrating shales of the Richmond group and Collingwood formation or saline-water-bearing zones in other aquifers. Pumping from various parts of fresh-water aquifers may result in local changes in ground-water regimen and may cause migration of water of inferior chemical quality from adjacent aquifers. In this manner, water of high sulfate content from the Cataract formation has entered basal members of the Burnt Bluff formation. Lastly, the shallow limestone and dolomite aquifers of Delta County, which are readily recharged through fractures and crevices, are highly susceptible to contamination from surface sources.--Auth.

3-2012. Zimmerman, Everett A. PRELIMINARY REPORT ON THE GEOLOGY AND GROUND-WATER

RESOURCES OF NORTHERN BLAINE COUNTY, MONTANA: Montana Bur. Mines & Geology, Bull. 19, 19 p., 5 figs., geol. map, scale 1 in. to 2 mi., Nov. 1960, 7 refs.

The geology and ground-water resources of northeastern Blaine County were investigated under a cooperative program between the U. S. Geological Survey and the Montana Bureau of Mines and Geology. The area includes rocks ranging in age from Late Cretaceous to Recent.

Limited supplies of ground water can be obtained from the Judith River, Fox Hills, and Hell Creek formations of Cretaceous age and deposits of Pleistocene and Recent age. Large supplies of water of good quality are available from the Flaxville formation, which underlies the Big Flat. The only source of recharge to the aquifer is precipitation falling on the plateau which it underlies. It is estimated that 5,000 acre-ft. of recharge is available for use from the Flaxville formation. Approximately 300,000 acre-ft. of ground water is in storage, and depletion of the aquifer is not imminent under present patterns of water use.--Auth.

3-2013. Eakin, Thomas E. GROUND-WATER APPRAISAL OF NEWARK VALLEY, WHITE PINE COUNTY, NEVADA: Nevada, Dept. Conserv. & Nat. Resources, Ground-Water Resources - Reconn. Ser., Rept. 1, 33 p., 5 illus., map, 3 tables, Dec. 1960, 17 refs.

The results of this reconnaissance indicate the average annual ground-water recharge to be on the order of 18,000 acre-ft. and the average annual discharge to be about 16,000 acre-ft. Lack of agreement of the 2 estimates may be because the estimate of discharge did not include an estimate of evaporation from the playa area. However, it is believed that the estimates are reasonable and indicate the general order of the quantity of ground water perennially circulating into and out of the ground-water system of Newark Valley. The estimates are compatible also with information developed in other valleys of Nevada where more extensive studies have been made. Refinement of the estimates, to be of value, would require a great many additional data not presently available. Substantial development of ground water in the valley would provide a means of obtaining part of the necessary data, and additional data could be obtained at such time as intensive investigation was economically warranted.

Ground water in storage has been estimated to be on the order of 15,000 acre-ft. per ft. of saturated thickness in the valley fill within the 150,000-acre area enclosed by the 6,000-ft. contour. The large amount of water in storage provides a substantial reserve for maintaining pumping during protracted periods of drought.

Locally, water quality and soil conditions may be limiting factors in agricultural development, particularly for crops less salt tolerant than those now grown in the valley. Additionally, the growing season apparently is so short that it should be carefully considered in planning further agricultural development.

The most favorable areas for initial prospecting for large ground-water supplies appear to be in the lower parts of the alluvial apron along the W., N., and NE. sides of the valley where wells of moderate to large capacity might be developed in the upper 500 ft. of the valley fill.--Auth. Summ.

3-2014. Walton, William C., and George D. Scudder. GROUND-WATER RESOURCES OF THE VALLEY-TRAIN DEPOSITS IN THE FAIRBORN AREA, OHIO: Ohio, Div. Water, Tech. Rept. no. 3, 57 p., 26 figs., 3 maps (in pocket), 6 tables, 1960, 13 refs.

The Fairborn area covers 40 sq. mi. in Greene County about 8 mi. NE. of Dayton. The Mad River flows southwestward through the area to a confluence with the Miami River at Dayton.

Glacial drift of late Wisconsin age lies at the surface in most of the area. Uplands are covered by till, mostly in the form of ground moraine, and the valleys in the bedrock contain thick and extensive deposits of sand and gravel called "valley-train" deposits. A wide, deep valley was carved into the bedrock surface in the western part of the area. The floor of the buried valley is more than 250 ft. below the land surface and about a quarter of a mile wide. Several small tributary buried valleys whose floors are more than 100 ft. below the land surface join the main buried valley in the area. The permeability of the valley-train deposits is high. Coefficients of permeability of 2,200 and 3,500 g.p.d. (gallons per day) per sq. ft. were determined from 2 pumping tests. The deposits in the main buried valley beneath the lowlands adjacent to the Mad River are more homogeneous and permeable than the materials filling a buried tributary valley NE. of Fairborn.

Shale of Ordovician age underlies the glacial drift throughout wide areas of the lowlands of the Mad River valley. The Ordovician shale is relatively impermeable, rarely yields more than 1 g.p.m. (gallon per minute) to wells, and is capped on the higher hills overlooking the Mad River valley by about 30 ft. of lower Silurian limestone. The yield of these Silurian rocks, averaging about 16 g.p.m. per well, is sufficient for domestic and farm use.

It is estimated that about 6 m.g.d. (million gallons per day) of ground water was withdrawn from the valley-train deposits in 1954, of which more than half was pumped by the Wright-Patterson Air Force Base, whose use of ground water increased from 1.0 m.g.d. in 1940 to 3.8 m.g.d. in 1950. The natural discharge of ground water occurring as underflow from the Fairborn area is calculated to be about 0.6 m.g.d. Total ground-water discharge to streams is estimated at 9 m.g.d., of which 5 m.g.d. is discharged into drainage ditches at the Wright-Patterson Air Force Base. Discharge of ground water to the atmosphere by evapotranspiration is estimated to average 2 m.g.d.

As shown by water-table contours, ground water in the area is moving from the uplands to the valley floors, toward either effluent streams or wells. Pumping of wells and draining of lowlands have considerably reduced ground-water discharge to the Mad River, but have not reversed at all places the natural slope of the water table toward that stream. The water table has been lowered below Mud Run and Hebble Creek, and water percolates from these small streams into the valley-train deposits. The infiltration rates for sections of these streams, as determined from streamflow measurements, ranges from 340,000 to 170,000 g.p.d. per acre.

More than half a million acre-feet of water is stored in the valley-train deposits in the Fairborn area. In the period Oct. 1954 through Sept. 1955 there was a net increase in ground-water storage of 1,300 acre-ft. The ground water in the valley-train deposits is recharged from the following sources: 1) precipitation within the area, 2) induced infiltration of surface water from Hebble Creek and Mud Run, and 3) subsurface flow from the valley walls. Recharge from precipitation is estimated to average about 12 in., or 32% of the average annual precipitation (37 in.), and totals about 10 m.g.d. Recharge by induced infiltration of surface water is calculated to be about 2.7 m.g.d. The total subsurface flow of water from the valley walls in the Fairborn area is estimated to be about 3.3 m.g.d., or approximately 160,000 g.p.d. per mi. of valley wall.

Except in the industrial area E. of Fairborn, the ground-water reservoir in the Fairborn area shows no indication of overdevelopment. Present withdrawals are far less than the available ground-water resources. If the water table is lowered below stream level by heavy pumping from wells adjacent to the Mad River, recharge from streamflow will occur. It is estimated that about 50 m.g.d. could be induced to flow from the Mad River into the valley-train deposits. The total recharge from precipitation, subsurface flow from the valley walls, and recharge from Hebble Creek and Mud Run is estimated to be about 16 m.g.d. The potential yield of the aquifer, therefore, is about 65 m.g.d. The flow in the Mad River (a minimum of about 130 m.g.d. during 90% of the time) is great enough to replenish large withdrawals from the valley-train deposits.--Auth.

3-2015. Marine, I. Wendell. WATER-SUPPLY POSSIBILITIES AT CAPITOL REEF NATIONAL MONUMENT, UTAH: U. S. Geol. Survey, Repts., Open-File Ser., geol. map and sec. (in pocket), 2 tables, 1961, 8 refs.

A water supply of 50 g. p. m. (gallons per minute) is estimated to be sufficient to supply the present and future water demand at the Monument. The Coconino sandstone of Permian age appears to be capable of yielding this quantity of water to a well between 1,500 and 2,700 ft. deep in the vicinity of Fruita. Recharge to this aquifer probably is principally from the Fremont River. Water derived from the Coconino sandstone should be of potable quality. A water supply of suitable chemical quality also could be obtained directly from the Fremont River.--Auth.

3-2016. Washington, Division of Water Resources. WATER RESOURCES OF THE NOOKSACK RIVER BASIN AND CERTAIN ADJACENT STREAMS: Its: Water Supply Bull. no. 12, 187 p., 63 figs., 9 pls. (in pocket), 49 tables, 1960, 41 refs.

The quantity and quality of water within the Nooksack River basin is adequate to meet the area's municipal, industrial, agricultural, and domestic needs for many years to come. With a planned and orderly development, the basin has a water resource potential at least tenfold the present known demand. The Nooksack River system contains adequate dam and reservoir sites with capacities for 100% flood control and development of 123,200 kilowatts of firm power. These figures represent single purpose evaluations of each storage site and would necessarily require some refinement for multiple-purpose projects. Further study of each site will be required to determine the extent to which multiple uses would be compatible. [Surface water resources are discussed].

Rock systems in the Nooksack River basin range in age from Devonian to Recent, with Tertiary sedimentary and pre-Tertiary metamorphic rocks predominating in the eastern upland and Pleistocene glacial sands and gravels and Recent alluvium being the chief materials of the Whatcom basin. Tertiary and pre-Tertiary rocks in the study area produce only small amounts of ground water, and in most cases where production is obtained from those rocks, the water quality is poor.

Major production of ground water is restricted almost entirely to the glacial sands and gravels and river valley alluvium found in the Whatcom basin and along valley floors of the Nooksack River and its 3 major forks. Wells produce from a few gallons per minute in areas of poor production to several hundred gallons per minute from the more permeable recessional outwash gravels of the Whatcom basin. No complete quantitative figures are available for the study area. However, observation wells indicate that the maximum safe sustaining yields of the major aquifers have not been attained, and much additional development can be made utilizing that water source.

Geohydrologic and climatic conditions of the Nooksack River basin suggest that present naturally occurring water supplies can be materially increased by the application of artificial recharge and weather modification as those processes become better refined.--From Auth.

3-2017. Sullivan, Walter. BIG WATER SUPPLY BELIEVED ON MOON: New York Times, v. 110, no. 37,707, p.8, col. 5. Apr. 20, 1961.

Water in good supply may exist on the moon at depths as shallow as 100 ft., according to Thomas Gold, Cornell University. Reports of active volcanism on the moon suggest the following geohydrologic process: deep volcanism drives steam from rock, which migrates toward the surface and condenses to water. Its loss through evaporation is prevented by a seal of ice at depths of about 100 ft.--M. Russell.

12. MINERAL DEPOSITS

See also: Stratigraphy 3-1804; Geochemistry 3-1890; Mineralogy 3-1933.

3-2018. Shea, Edward P. THE ROLE OF THE GEOLOGIST AT BUTTE: Mining Engineering, v. 13, no. 3, p. 264-268, 3 illus., graph, March 1961.

Since 1900, when it was organized, Anaconda's geological department at Butte has successfully employed standardized methods. Guided by the geologic record, the geologist works closely with mine operators, pursuing a policy of developing at least one ton of new ore to replace every ton mined. A formal estimate of reserves is made on the first of each year, and the geologist estimates the tonnage developed weekly to determine the current status. A geological research department with a well equipped laboratory is maintained to investigate rock alteration, and extensive studies are in progress to relate alteration to mineralization and grade in both vertical and horizontal dimensions. An exhaustive study of Butte mineralogy is under way to obtain better knowledge and understanding of the behavior of the ore minerals at the time of deposition. This information will be used to predict deep-level possibilities and locate the zones of better Cu mineralization. The value of former records is demonstrated by comparatively recent projects - such as the Kelley and Elm Orlu cave mines and the Alice and Berkeley pits - which originated in the geological department.--Auth.

3-2019. Grabovsky, M.A., and others. **THE USE OF MAGNETIC POWDER IN STUDYING THE COMPOSITION OF IRON ORES:** Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 7, p. 647-650, 3 figs., pub. 1961, 10 refs.

Covering the polished surface of the specimen with magnetic powder and examination of its precipitation pattern under the microscope enables the authors to: 1) Recognize minute grains and inclusions of magnetite (down to 0.005 mm.) in ores. 2) Detect in the magnetite grains tiny inclusions of nonmagnetic minerals which the optical method reveals only at maximum microscopic magnifications. 3) Distinguish easily between individual grains of pure magnetite and ilmenite in titanomagnetite aggregates; and to draw conclusions from the density of the powder layer on titanomagnetite grains (which represent a disintegration structure of solid solutions) concerning the preponderance of magnetite resp. ilmenite in them.

The authors believe that the possibilities of the powder method in mineralogical investigations are not limited to the examples discussed in this paper.--Auth. concl.

3-2020. Riddell, John E. **GEOCHEMICAL TECHNIQUES - A REVIEW:** Can. Mining & Metall. Bull., v. 53, no. 582, p. 765-768, Oct. 1960, 47 refs.

A literature review of developments in applied geochemistry in the past 2 years in the U. S. S. R. and elsewhere.--P. R. Eakins.

3-2021. Amstutz, G. C. **SYNGENESIS AND EPIGENESIS IN PETROGRAPHY AND THE STUDY OF MINERAL DEPOSITS.** Translated by the U. S. Atomic Energy Commission: Internat. Geology Rev., v. 3, no. 2, p. 119-140, Feb. 1961; no. 3, p. 202-226, March 1961, chart, table, approx. 280 refs.

Many vital problems of rocks and mineral deposits are presently linked to criteria for syngenetic or for epigenetic origin. Two opposite schools of thought teaching these 2 different modes of origin have developed with regard to the origin of such major groups of ore deposits as the Mississippi Valley type, the red-bed Cu and U type, the native Cu in lavas, the Blind River or Witwatersrand type, the porphyry Cu, porphyry Mo or porphyry Fe type, the Lake Superior Fe and the Kiruna Fe type, the Bushveld type, etc. It is significant that the same 2 patterns of thought have developed largely independently in the discussion on the origin of granites, spilites, cherts, dolomites, oil deposits, the origin of the continents, the moon craters, etc.

The syngenetic and epigenetic theories of patterns of thought are illustrated and discussed on the basis of the following groups of phenomena: A) sedimentary rocks and ore deposits in them; B) intrusive rocks and ore deposits in them; C) extrusive rocks and ore deposits in them; D) tectonic and extra-terrestrial phenomena.

A comparison of genetic criteria used in discussions of these rocks and mineral deposits and of the 2 patterns of reasoning showed that the subdivision into a magmatic and a metasomatic or diffusionist school is less significant and basic than is the subdivision into epigenetic and syngenetic patterns of thought. These patterns can also be found in other sciences and in all other domains of human spirit. Light is thrown on the nature and role of these and other patterns, and it is shown that their recognition and analysis will eliminate old dogmatic misunderstandings and misinterpretations.

An attempt is made, using numerous examples of genetic problems in petrography and the study of mineral deposits, to arrive at a temporary stand in regard to the different theories of today. This will be done with the aim of achieving an integrated, wholistic view, and this will necessitate moving out of the limits of the actual discipline somewhat. We will examine our theories, and methods of investigation and trends of thought, as well as consider the roots of our geological "Weltbild," bringing them into the realm of our investigations. This last step, hardly begun in this work, will most of all require a firm knowledge of the history of the geological sciences.--From auth. summ.

3-2022. Perry, Vincent D. **THE SIGNIFICANCE OF MINERALIZED BRECCIA PIPES:** Mining Engineering, v. 13, no. 4, p. 367-376, illus., secs., Apr. 1961, 16 refs.

The widespread occurrence and close relation of breccia pipes to many great ore bodies give them unusual importance. They are chimneylike masses of brecciated rock, circular, oval, or polygonal in plan outline, with steep axes proportionately much greater than their horizontal dimensions. Impressive downward displacement or slumping of identifiable rock fragments and the development of characteristic void spaces within the breccia columns are evidence for removal of large volumes of the original rock. Since the tops of many pipes are covered and sealed by unbroken roofs, the evidence is conclusive that removal of material must have occurred from below. Rock in the breccia chimneys may be broken by the removal of underlying support at the active summits of fluid magma columns. Pressure readjustment and magma withdrawal would result from developing disequilibrium, caused by volcanic or fissure eruption in a neighboring part of the system. Thus, advancing, localized subsidence may be a fundamental response, in a reciprocal sense, to be repeated spasms of dying volcanism. A corollary of the process is the creation of foci of reduced pressure within growing breccia chimneys and the consequent localization of end-stage, mineral-rich vapor and liquid phases, distilled from the crystallizing magma and attracted to these broken low pressure zones in the rock.

The significance of mineralized breccia pipes is that they are climactic expressions of general processes which, under differing local conditions, may also form the ring or dome-shaped fracture zones that control certain porphyry Cu deposits. Thus, they provide clues to the origin of many of the world's great ore bodies, including Anaconda's La Colorada mine at Cananea, Mexico, and the new El Salvador mine in Chile. Analysis and understanding of these and similar structures may help to solve problems of scientific and economic importance related to processes controlling the collection, circulation, and deposition of mineralizing fluids.--Auth. summ. & concl.

3-2023. Ovchinnikov, L.N. **SOME PROBLEMS OF MAGMATIC MINERALIZATION:** Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 4, p. 16-29, 10 figs., pub. 1960, 42 refs.

This paper deals, on the basis of modern physical and chemical concepts and experimental and geologic data, with the internal structure of magmatic melts, with the form of the occurrence of chemical elements in them, and with the mechanism of the differentiation of ore substance and of metals from the magma. --Auth.

3-2024. Turovsky, S.D. THE AGE RELATIONSHIPS OF IGNEOUS DIKES AND POST-MAGMATIC MINERALIZATION IN THE DEPOSITS OF NORTHERN KIRGHIZIA: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 6, p. 75-86, 2 tables, pub. 1961, 19 refs.

Many geologists, including the author, think that all dikes, regardless of composition and time of separation from the magma source, are formed previous to the mineralization process relative to the postmagmatic, especially hydrothermal, mineralization which originated from the same chamber. Other geologists think that each magmatic phase includes dikes formed previous to, during the course of, and subsequent to the mineralization process. Study of mineral deposits of northern Kirghiz S.S.R. proves the correctness of the first viewpoint. These deposits have been formed in 3 separate magmatic phases. The first phase is tentatively Devonian, the second phase is tentatively Carboniferous, and the third Upper Permian. Ore-bearing elements of the third phase were first alaskite and then alkali. The Granitnaya Gorka Pb ore deposit belongs to the first Devonian metallogenic phase. Numerous andesite-porphyrite dikes in these deposits were obviously formed previous to the mineralization process, because they are cut by thin veins filled with ore. The same can be said of dikes in the Ak-Tash-Koro, Taldy-Bulak, and many other deposits of the region. The earlier formation of dikes found in the Aksu group deposits is also obvious, with an exception made for lamprophyre dikes, which are considered as having been formed after the ore-formation process. Detailed study of these dikes, fixes their occurrence before mineralization. One of the proofs of earlier origin is that the primary accessory minerals - pyrite, apatite and zircon - contained in the lamprophyres were exposed to the dissolving action of some reagent which could only be the ore-bearing solutions. The Ak-Tyuz and Kutes-Say polymetallic deposits were formed during the last Upper Permian metallogenic phase and associated with the alaskite magmatic source. Dikes were composed of granophyres, aplites and of different porphyrites. Microscopic study disclosed evidence of dissolving action of the ore-bearing solution on the primary accessory minerals, zircon, apatite, anatase, magnetite, and pyrite. Dikes of the Boordu polymetallic deposit of the Devonian metallogenic phase are partly beresitized and mineralized by ore-bearing solutions, so that their earlier origin is also obvious. The syenite-diorite dikes, also occurring in this deposit, are classified by the author as belonging to another, much younger Upper Permian metallogenic phase, because they are completely different from other dikes and have many features common with syenites and granosyenites of the Upper Permian, common in the adjacent region. The polymetallic and rare metal ore deposits of Kurgan were formed in 2 different metallogenic phases. Earlier formation of the diabase-porphyrite is obvious. Dikes of the Upper Permian rare metal ore deposits formed of aegirine syenites and syenite aplites were mostly submitted to the action of the alkaline ore-bearing solution and partly transformed by them, thus proving that their emplacement is previous to the ore deposits. Age correlation between dikes composed of basic porphyritic rocks and of the postmagmatic mineralization is more difficult to determine because the chemical inertia, plasticity, and toughness of porphyrites make them resistant to the action of different ore-bearing reagents and to the tectonic movement of the enclosing bodies.--From LC.

3-2025. Aletan, George. THE SIGNIFICANCE OF MICROSCOPIC INVESTIGATION IN THE COURSE OF BENEFICIATION OF THE "BRUNSWICK ORE": Can. Mining & Metall. Bull., v. 53, no. 584, p. 945-952, 24 illus., table, Dec. 1960, 3 refs.

The paper illustrates the complex nature of the massive sulfide ore of the Brunswick Mining and Smelting Co. deposit near Bathurst, New Brunswick. The complex mineralization was caused by: 1) rhythmic fractional precipitation and partially very fine crystallization of all minerals involved; 2) mutual intergrowths and replacements, particularly of pyrite by galena and chalcopyrite; 3) partial alteration of Cu and oxidation of Pb minerals; 4) infiltration of secondary Cu minerals into sphalerite, galena, and pyrite; 5) precipitation of Fe as magnetitie in galena; 6) exsolution of chalcopyrite in sphalerite; 7) association of very fine graphite with pyrite, sphalerite, and galena.

The problems of beneficiation and the usefulness of microscopic investigations in solving such problems are stressed.--P.R. Eakins.

3-2026. Tuzikov, R.P. SOME FEATURES OF THE ORIGIN OF THE URUP PYRITE DEPOSIT (NORTHERN CAUCASUS): Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 5, p. 85-93, 10 figs., pub. 1960, 6 refs.

Data on the relationship of ore bodies, zones of pyritization, and their textures, with the schistosity of enclosing rocks and dikes which cut the latter, lead to the conclusion that ore bodies in the Urup pyrite deposits were formed in already schistose rocks and have not undergone regional metamorphism.

The lower age boundary for the Urup pyrite deposits is the time of intrusion of the pre-ore dikes which cut the Devonian metamorphics; the lower boundary is middle Carboniferous deposits not affected in this area by either the igneous or hydrothermal activity.

The age of the metamorphic sequence, which we have assigned to the Devonian, is uncertain. An older age is not to be ruled out.

The Urup ore bodies and zones of pyritization represent mineralized zones of postfolding normal faults.--Auth. concl.

3-2027. Baklakov, M.S. A VOLCANOGENIC STRATUM IN THE CENTRAL CAUCASUS AS A POSSIBLE SOURCE OF SEDIMENTARY LEAD AND ZINC DEPOSITS: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 6, p. 87-92, map, table, pub. 1961, 13 refs.

A discussion of different theories on the possibility of sedimentary origin of Pb and Zn deposits, either in marine or continental conditions. A. A. Kudenko indicates that these metals are usually found in volcanic effusive rocks. According to him, limestones, and especially bituminous rocks, are the most probable place where Zn and Pb could be accumulated. The author gives a detailed description of a volcanic horizon partly outcropping and partly covered with Liassic deposits in the territory of upper Osetiya, central Caucasus. This horizon, composed of effusives and pyroclastics was formed as a result of an intensive volcanism in the lower Liassic. Pyroclastic beds, composed of albitophyres, porphyrites, and dacites, were in some places interstratified with normal sedimentary beds. In these effusive beds, the author found large grains of pyrite and smaller ones of sphalerite and galenite. The average Zn content was 0.08% and that of lead 0.035%. This volcanic horizon was eroded 3 times during the Jurassic, and it is possible that the washed-out ore components, particularly Zn and Pb, were carried away into the transgressive sea and formed a sedimentary ore deposit. The main sources of Zn and Pb in the central Caucasus are the effusive and pyroclastic beds of the volcanic horizon. The author recommends their careful lithologic study and sampling. --From LC.

3-2028. Borisenko, L.F. SCANDIUM IN DEPOSITS OF DIFFERENT GENETIC TYPES: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 4, p. 41-47, table, pub. 1960, 12 refs.

Sc, discovered by Nilson in 1879, is little known and of no wide practical application because of its wide dispersal in rocks and the extreme rarity of deposits. As the only 2 known Sc minerals, thortveitite and bazzite, do not form large deposits, the author concentrates on ores and minerals where Sc is present as an impurity in proportions 16 to 300 times greater than its Clarke Index. Most of the known Sc-bearing ore deposits belong to the pegmatite and pneumatolytic-hydrothermal types. A characteristic feature of most endogenetic Sc-bearing deposits is their genetic connection with granites. Pneumatolytic-hydrothermal deposits may be found in albitized granites, greisen and quartz-greisen deposits, skarn, and carbonatite ore deposits. Exogenic Sc deposits in placers and sorption sedimentary ore deposits may offer sources in the future. It is concluded that the greisen type of wolframite, cassiterite, and beryl ore deposits present the most probable source of Sc at present.--A. Eustus.

3-2029. Vasilkova, V.N. METASTABLE K-FELDSPAR AND ZEOLITE IN ORES OF THE DALNETAYEZHNYY (FAR TAIGA) DEPOSIT: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 5, p. 94-98, 4 figs., 3 tables, pub. 1960, 3 refs.

The sulfide-cassiterite Sn ores of the Dalnetayezhnyy deposits in the Soviet far eastern maritime region were formed near the earth's surface far from a magmatic source. There is close dependence of conditions of formation of sulfide-cassiterite deposits on the depth of formation of intrusive rocks. In consequence, all such deposits are divided into 3 groups 1) deposits spatially and genetically related to magmatic bodies now exposed; 2) deposits not directly linked with a magmatic source, but having contact-metasomatic aureoles with regular mineral changes; 3) deposits having neither direct nor indirect links with intrusive rocks. Deposits belonging to the first 2 groups were formed under conditions of sharp changes of temperature: high initial temperature in the process of crystallization of ores and lower temperature during the ore formation process. This explains the occurrence of peculiar mineral forms and mineral associations, as observed in the Dalnetayezhnyy deposits. These deposits present a complicated system of mineralized breccia zones in the Mesozoic sandstone-slate. Magmatic formations of the deposits consist of large dikes of granite-porphyries, various porphyrites and lamprophyres. The ores were formed in the following main stages of mineralization: 1) arsenopyrite quartz with K-feldspar; 2) pyrrhotite; 3) pyrite-ankerite; 4) the quartz-adularia, ending with the deposition of pyrite and calcite. The author describes the association of K-feldspar and zeolite with cassiterite, never before described. There are 2 generations of K-feldspar, the first associated with quartz-cassiterite ores, the second intergrowing with the later oreless quartz. Both generations have identical physical, optical, and other features. Analyses show a relation between K-feldspar and the sanidine-like form, which in the process of crystallization of ores, is replaced by adularia. The sanidine is a high temperature variety of the orthoclase. The K zeolite-leonhardite is the principal component of the cassiterite-zeolite ores filling one of the veins of the Dalnetayezhnyy deposit and is also found in pockets in sandstone of the deposits. Zeolite in these ores is closely associated with quartz, cassiterite, arsenopyrite, and Ca-containing minerals: actinolite, fluorite, axinite, and epidote.--From LC.

3-2030. Danchev, V.I., and V.V. Olkha. SOME PROBLEMS ON THE ORIGIN OF URANIUM MINERALIZATION, IN CONNECTION WITH THE STUDY OF EFFECTIVE POROSITY OF ORE-BEARING CARBONATE ROCKS: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 7, p. 12-20, 6 figs., pub. 1961, 15 refs.

Effective porosity of sedimentary carbonate rocks is closely related to structural features. Of the varieties studied, oölitic limestones have the lowest effective porosity (4.3%); it is somewhat higher in organic limestones (5.2%), and it is about twice as high in crystalline carbonate rocks (10.2%).

The most widely developed ore-bearing carbonate rocks of our type of sedimentary U deposits are marked by the lowest effective porosity.

Mineral dissemination predominates where the rock is least affected by the processes of recrystallization, leaching, etc. Samples of such rocks are marked by minimum effective porosity. This is in full agreement with the concept of a primary sedimentary origin of the mineralization.--Auth. concl.

3-2031. Kelly, William C. SOME DATA BEARING ON THE ORIGIN OF JAMAICAN BAUXITE: Am. Jour. Sci., v. 259, no. 4, p. 288-294, fig., 3 tables, Apr. 1961, 13 refs.

Twenty-nine samples of the White Limestone formation from Kendal, Jamaica, have been analyzed for SiO_2, Al_2O_3, and Fe_2O_3. As the bedrock of the aluminous soils in Jamaica and Hispaniola, the impurity content of this unit has an important bearing on the origin of the bauxite deposits. The average alumina content of the limestone indicated by these analyses is 0.036%. This figure corresponds to a tentative value given by Goldich and Bergquist and confirms their calculation of the thickness of limestone that would have to have been dissolved to account for the present reserves of ore on the Rochelais plateau in Haiti. The unusual ratios of alumina to silica indicate the presence of excess alumina in the limestone, possibly as aluminum phosphates or alumina hydrates. Efforts at isolating the Al-bearing minerals by acid leaching have so far been unsuccessful. The Al_2O_3:Fe_2O_3 ratios of the limestone as determined from these analyses correspond to Al_2O_3:Fe_2O_3 ratios in the bauxite. Such correspondence cannot be taken as evidence that the ores are insoluble residues of the limestone. Both the bauxite and the limestone may have derived their iron oxide and alumina from the older aluminous rocks exposed in the higher central parts of the island.--Auth.

3-2032. Warning, G. F. GEOLOGY OF THE H.B. MINE: Can. Mining & Metall. Bull., v. 53, no. 582, p. 769-772, 4 figs., Oct. 1960, 4 refs.

The H.B. mine is situated on the N. side of Sheep Creek valley about 6 mi. SE. of Salmo, British Columbia, and 23 mi. N. of Metaline Falls, Washington. The H.B. mine and other Pb-Zn producers of the Salmo district are located in the Reeves limestone of the lower Laib group, a narrow curving band of deformed calcareous rocks of Lower Cambrian age. The H.B. ore bodies are confined to a synclinal zone of the Reeves limestone where it has been thickened by isoclinal folding. The ore zone is a few hundred feet from a major thrust fault separating the Reeves from Ordovician Active argillite. All the ore bodies occur in dolomitized limestone, and are of 2 main types: 1) lenticular pipelike zones of steeply dipping stringer lodes plunging 20°S., and 2) flat-dipping mineralized breccia zones. The ores are made up of fine-grained pyrite, sphalerite, and galena.--P.R. Eakins.

3-2033. THE REEVES MACDONALD OPERATION: Can. Mining & Metall. Bull., v. 54, no. 586, p. 143-147, 5 figs., Feb. 1961.

The Reeves MacDonald mine is located between the valleys of the Pend Oreille and Salmo rivers in southern British Columbia. From 1947 to 1959 the mine has produced over 2 million tons of ore containing approximately 41.5 million lbs. Pb, 170 million lbs. Zn, 991,965 lbs. Cd, and 167,949 oz. Ag. The Pb-Zn ore bodies are sulfide replacement deposits in the Reeves limestone member of the Lower Cambrian Laib formation (Maitlen phyllite of the Metalline district), and are similar to those of the H.B. and Jersey mines. The deposits all occur in the Reeves limestone on the footwall side of a major thrust fault, and are enveloped by dolomite zones. Secondary structural features have apparently played a significant role in localizing the various ore bodies.

The Reeves ore body occupies a large secondary synclinal trough developed on the S. limb of the Salmo River anticline, a gently plunging isoclinal fold whose axial plane dips 60°S. The secondary isoclinal folds superimposed on the major anticline plunge S. 15-35°W. at 50-55°. Bedding faults apparently related to the secondary folds complicate the structure. The most important faulting from a mining point of view consists of shallow-dipping (25°-40°) normal cross faults which disrupt into 4 segments the Reeves ore body, which had an original plunge of length of at least 5,000 ft.

The main ore body is localized entirely within a dolomitized zone of Reeves limestone and has a synclinal form which appears to parallel closely that of a surrounding tight syncline. The principal sulfides are pyrite, honey-colored sphalerite, and galena replacing banded dolomite. Some breccia consisting of limestone and dolomite fragments in a massive sulfide matrix is present along part of the footwall.--P.R. Eakins.

3-2034. Campbell, Finley A. NICKEL DEPOSITS IN THE QUILL CREEK AND WHITE RIVER AREAS, YUKON: Can. Mining & Metall. Bull., v. 53, no. 584, p. 953-959, 7 figs., 2 tables, Dec. 1960, 12 refs.

Ni-Cu sulfide deposits associated with basic rocks in the Quill Creek area and the White River area in the Yukon Territory have been studied and compared from the viewpoint of their general geology, structural geology, and the mineralogy of the ores. The relative amounts of the major constituents, Mg, Fe, and Ca, and the minor constituents, Ni, Co, and Cr have been determined spectrographically for 2 cross sections of the basic rocks at Quill Creek and 1 at White River. These data, along with petrologic and field evidence, were used to determine the sill and dike-like character and nature of the basic intrusions. Loss on ignition is employed as a measure of the degree of serpentinization. The distribution determined shows that the serpentinization does not appear to have greatly influenced the inferred original distribution and lithophile associations of Mg and Ni. The Co content may have been altered.

The Ni content of the serpentinized peridotites ranges from an average of 0.36% in one section to an average of 0.24% in each of the other 2 sections studied. The Co averages 0.0038% in the samples from the 2 Quill Creek sections and averages 0.0042% at White River. These results have been compared with other available data.

The sulfide ores are later than both the peridotite and gabbroic rocks and may be comagmatic with them. There is no evidence in these areas to support an origin by lateral secretion; on the contrary, the alteration associated with the ores, the mineralogy and spatial relationship to basic and ultrabasic rocks, indicate the ores are derived from a basic magma.--Auth.

3-2035. OLD DISTRICT - NEW DEPOSIT. MCA EXPLORATION FINDS LARGE MOLYBDENITE PROSPECT: Mining Engineering, v. 13, no. 1, p. 14-15, 2 illus., map, Jan. 1961.

New Mexico may contain a molybdenite deposit second only to that at Climax, Colorado. The new Mo prospect, approximately 1 mi. W. of the old Questa mine, comprises 2 separate, but nearby ore bodies at depths exceeding 1,500 ft.

Questa is underlain by early Tertiary volcanics ranging from andesites to welded rhyolitic tuffs. This volcanic series was intruded during the late Tertiary by granite porphyries, porphyritic aplites, and rhyolite porphyries.

The molybdenite occurs principally in small veinlets within well-developed vein systems varying in width from several inches to more than a foot. The mineral is also found along fault planes within the country rock. It is thought that the introduction of the molybdenite and associated pyrite occurred after the reopening of small fractures within the host rocks. Evaluation of findings indicate that the ore bodies will attain or exceed an average molybdenite content of 0.5%.--From auth., p.14,15.

3-2036. Colorado, Metal Mining Fund Board. TUNGSTEN MINES OF COLORADO: 78 p., 204 State Office Building, [Denver], Jan. 1960.

The history of W in the United States is a history of "boom and bust," with periods of intense exploration and production followed by periods of almost complete abandonment of the mines. During these periods of nonoperation, facts relating to the mines often become distorted or completely forgotten; the actual location of mines sometimes becomes lost, as has a large group of small mines listed in this report, mines which were designated prospects upon a large agricultural patent, but which now appear to be completely lost, unknown even to the owning company and to its previous mine superintendents.

The Metal Mining Fund of the State of Colorado has therefore deemed it advisable to compile certain basic facts concerning the W mines of the state. This tabulation is not to be considered an evaluation of any property, but is limited to brief essential information which would offer a starting point in future mine investigations.

Information is as of Jan. 1, 1960. An effort has been made to tie each property to some generally known landmark, so that its position may be recognized even after the lapse of several years. Owner addresses have not been given, as ownerships are subject to change. Ordinarily such addresses may be obtained from county records.

Remarks under "Potential" have, in the main, been avoided, as there is no intention or desire to promote or discredit any property. If the last operator offered a factual observation which could be utilized as a clue in future exploration, this has been listed, otherwise "Potential" has been given as "Unknown."

When properties have been operated under DMEA contracts, maps were filed with both the U. S. Bureau of Mines, and with the U. S. Geological Survey. The notation "USGS" refers to this, but does not ensure availability of the maps to the general public.--From introd.

Mines are listed alphabetically by name.

3-2037. Fischer, Richard P. VANADIUM-URANIUM DEPOSITS OF THE RIFLE CREEK AREA, GARFIELD COUNTY, COLORADO. With a Section on Mineralogy, by Theodore Botinelly: U. S. Geol. Survey, Bull. 1101, 52 p., 8 figs., 10 pls. (4 in pocket, incl. geol. map, scale 1:31,680), 3 tables, 1960, 30 refs.

One of the largest V-U deposits in the Colorado Plateau region is in the Navajo(?) and immediately overlying Entrada sandstone in the Rifle Creek area. These formations total about 150 ft., and both are composed of clean, massively cross-bedded, fine-grained sandstone. This deposit, consisting of V ore with a little U, is well exposed by mine development and therefore suited for study and interpretations of structural features, ore habits, and geochemical relations.

The ore minerals consist mainly of micaceous, fine-grained, V-bearing silicates that impregnate the sandstone. The ore occurs in 3 overlapping layers, each of which is tabular and lies generally parallel to the major bedding. Each layer is bordered on one side by a very thin band of finely disseminated galena and clausthalite, beyond which is a thin greenish layer containing micaceous Cr-bearing silicates. The galena-clausthalite band and the Cr-bearing layer lie above the lower and upper V ore layers but below the middle V layer.

The lower V layer underlies the entire deposit, but the middle and upper layers are partly discontinuous. If, however, the separate parts of the middle and upper layers are connected by imagined links, the 3 layers have a broad S-shaped pattern about 80 ft. high and 10,000 ft. long, for the middle layer is connected to the lower layer at the E. end of the deposit and to the upper layer at the W. end.

Small V-U deposits in the Morrison formation are also described.--Auth.

3-2038. Starostina, Z. M. CONDITIONS OF DISTRIBUTION OF SIDERITE ORES THROUGHOUT THE HOST ROCKS OF THE BAKAL' GROUP OF ORE DEPOSITS, SOUTHERN URALS: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 7, p. 33-50, 9 figs. incl. maps, secs., pub. 1961, 21 refs.

On the basis of her study of the occurrence of the Bakal siderite ores, throughout the section and areally, the author comes to the conclusion that these ore deposits are associated with definite facies conditions during their sedimentary origin. The richest sideritic facies follow a clean-cut latitudinal trend in the area of the Bakal group of ore deposits. The over-all ore-bearing zone trends NE. This latitudinal trend does not agree with the northeastern trend of the present tectonic structures and appears to be connected instead with the tectonic development of the Ural foredeep as a whole, where it joins the Ufa plateau.--Auth.

3-2039. Gurova, T. I., and E. G. Sorokina. ON THE UPPER CRETACEOUS IRON ORES IN THE EASTERN PART OF THE WESTERN SIBERIAN LOWLAND: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 6, p. 47-54, map, pub. 1961, 5 refs.

The Upper Cretaceous Fe ores in the eastern part of the western Siberian lowland are hydrogoethite-leptochlorite-siderite oölitic nearshore marine formations. The ores richest in Fe are of Turonian age and extend to a fairly large distance laterally; the depth of their occurrence decreases as one moves toward the E. and SE.

The points at which it has been indicated that Fe ores occur testify to the extensive development of facies conditions favorable to their formation throughout the territory of the western Siberian lowland in the Upper Cretaceous. Further geologic prospecting should discover industrially valuable deposits of Fe ores in this area.--Auth. concl.

3-2040. Goodwin, William. OUTLOOK FOR ALUMINUM: Focus, v. 11, no. 5, p. 1-6, 5 maps, Jan. 1961, 6 refs.

The construction industry is the largest consumer of Al, followed by the auto and other industries.

Bauxite is the prime ore, found mainly in Australia (2 billion long tons reserves), Guinea (600 million), and Jamaica (550 million). Other major deposits are in Hungary, Ghana, Surinam, Yugoslavia, and the Soviet Union. Bauxite is processed to yield alumina (aluminum oxide) in plants close to the deposits, except for Caribbean bauxite processed in Gulf Coastal plants.

Electrolytic reduction of alumina to Al is normally conducted in plants near cheap, abundant hydroelectric power. The United States produces 2.6 million tons annually in plants on the East Coast and in the Pacific Northwest near hydroelectric power, on the Gulf Coast from electricity from natural gas, and along the Ohio River where locally generated power and proximity to Al consumers combine to maintain competitive prices. Canada produces 1 million tons annually on the E. Coast and in British Columbia.

The Soviet Union produced 605,000 tons of Al in 1958 with 1,400,000 tons planned by 1965 in plants largely E. of the Ural Mountains.

The rest of the world produced nearly a million tons in 1959 in France, West Germany, Norway, Japan, and other countries. Australia's disproportionate reserves discovered in 1956 indicate it could be a major producer with development of power.

Other underdeveloped countries with large reserves lack production facilities because of lack of power, lack of capital, or because of government hindrance. --E. A. Gribi, Jr.

3-2041. Nozdrin, P.I. NEW DATA ON MESOZOIC BAUXITES DISCOVERED ON THE EASTERN SLOPE OF THE SOUTHERN URALS: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 4, p. 85-87, sec., table, pub. 1960.

Two distinct beds of bauxite, separated by clays, were located by borehole in the Krutoy spring valley. Subsequent drilling shows the bedrock to be represented by lower Carboniferous limestones. The bauxite apparently occurs in karst holes or in depressions of Cretaceous through Quaternary age. Further bauxite prospecting of the southern Urals' eastern slope is urged.--A. Eustus.

3-2042. Pearson, W.J. DEVELOPMENTS IN POTASH IN SASKATCHEWAN: Can. Mining & Metall. Bull., v. 53, no. 582, p. 759-764, table, Oct. 1960, 13 refs.

A brief review of the history, sources, and uses of "potash" prefaces a description of the geology, mineralogy, grade, and reserves of potash deposits in Saskatchewan. The development of the deposits is covered in some detail. Markets and future outlook are discussed.

The Saskatchewan potash is of Middle Devonian age and occurs in beds near the top of the Prairie Evaporite formation of the Elk Point basin. The 3 predominant minerals in the potash-bearing beds are halite, sylvite, and carnallite. Polyhalite and leonite have been reported.

The grade of the Saskatchewan deposits probably will be in the range of 25 to 35%, and generally higher than the potash deposits being mined in New Mexico and Europe. Reserves are estimated at 6.4 billion tons, a figure which exceeds estimates of previously known world reserves.--P.R. Eakins.

3-2043. Cadilla, José F. A CLAY FOR A LIGHTWEIGHT AGGREGATE: 62 p., 2 maps, diag., 8 tables, [San Juan?], Puerto Rico Economic Development Administration, Dept. of Industrial Research, June 1960, 31 refs.

A clay body for the manufacture of a good lightweight aggregate is shown. An area of 11 sq. km. holding 12 million short tons, at least, of surficial clays with an average Ca^{++} percent of 0.25, lies to the immediate N. and E. of the town of Carolina, and is accessible through paved roads P.R. 3 and the road leading to Colonia Monserrata, in Hoyo Mulas, Carolina.

An aggregate, C-H prepared as a representative sample of the area, was bloated at cone 3 (1,168°C.) and developed a unit weight to 58.5 lbs./cu. ft., and an apparent specific gravity of 1.8.

Two lightweight concrete aggregate mixtures, C-H-a and C-H-b, were prepared with the C-H aggregate totally replacing the coarse and fine aggregates of normal-weight concrete, with a 1:6 aggregate-to-Portland cement ratio, and only differing in the water content. Following standard procedures of testing, the C-H-a mixture, with 58.3 gallons of water per cubic yard of concrete, developed a unit weight of 101 lbs./cu. ft., a compressive strength of 2,625 lbs./sq. in., and an absorption of 18%. The C-H-b, with 50.9 gallons of water per cubic yard of concrete, developed a unit weight of 105 lbs./cu. ft., a compressive strength of 2,980 lbs./sq. in., and an absorption of 15%. Both the lightweight aggregate and the concrete aggregate comply with the technical requirements set forth by industry.

The doubtless existence of other bloatable clays in different regions of Puerto Rico encourages further research by private industry.--Auth.

3-2044. Saskatchewan, Dept. of Mineral Resources. SUMMARY OF GEOLOGICAL SURVEYS CONDUCTED IN THE PRECAMBRIAN AREA OF SASKATCHEWAN, 1960. By R.L. Cheesman and others: 21 p., map, [Regina], 1960.

The surveys described in this summary report represent many areas of widely differing geology, but they assist in studies directed towards subdividing the Precambrian of Saskatchewan into distinct geological subprovinces, based upon lithology, structural features, and metamorphism. In addition they serve to indicate areas worthy of priority in attention by prospectors and exploration companies.

From an economic aspect, 2 zones stand out as worthy of more immediate prospecting attention. One is the zone trending northeasterly from Lac la Ronge to Southend on Reindeer Lake, as represented in this report by the Otter Lake and Settee Lake areas and by the southeastern part of the Deception Lake area. The other zone lies in the noritic rocks and associated garnet-pyroxene and garnet-hornblende gneisses N. of Stony Rapids. Both zones have been the subject of prospecting for many years, but there is still room for concentrated and detailed work.

In the Lac la Ronge-Reindeer Lake zone many of the obvious magnetic anomalies obtained in airborne surveys have proved disappointing, as they commonly represent occurrences of pyrrhotite mineralization, barren of Ni, and commonly of probable sedimentary origin. The surveys summarized here, as well as work in Otter and Trout lakes in 1959, and at Brabant Lake in 1958, indicate that Cu, Pb, Zn, and Au mineralization, while not causing such marked geophysical anomalies, occurs in significant amounts. In the Stony Rapids area, pyrrhotite mineralization appears to be of a different type and is associated with Ni values. Here geophysical surveys might prove a valuable aid in delineating further economic occurrences.

Mineralization in the other areas mapped is less prominent, although the Attitti Lake area near Flin Flon merits attention. It is of significance in the over-all studies in Saskatchewan that the areas of Barnett Lake and Thainka Lake, which both contain major faults of considerable extent are markedly lacking in economic mineralization. This is also to some extent true of the Brûlé and George lakes area which were subject to shorter investigations.--Auth. concl.

3-2045. EXPLORATION IN 1960: Mining Engineering, v. 13, no. 2, p.153-156, 3 illus., Feb. 1961.

From the viewpoint of the independent geologist, the general level of exploration activity in 1960 was not appreciably better than in the previous year. With one exception, there was little intense exploration anywhere E. of the Rocky Mountains. Over all, there there were 3 centers of interest in the U.S.: the search for Cu in Arizona; for Pb, Zn, and Fe in Missouri; and for Be - anywhere.--Auth., p.153.

3-2046. Smirnov, V.I. EXPERIENCE IN THE METALLOGENIC REGIONAL ZONATION OF THE U.S.S.R.: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 4, p. 1-15, map, chart, pub. 1960, 15 refs.

An outline of the metallogenic zonation of the U.S.S.R., on the principle of the separation of distribution areas of Alpine, Mesozoic, Hercynian, Caledonian, and Proterozoic endogenetic ore deposits. The mineralization of the provinces of the Soviet Union is established as being polycyclic in character by the occurrence within the provinces of ore deposits of several metallogenic times. The associations between the mineralizations of the preceding and subsequent epochs and certain features of the general evolution of endogenetic mineralizations from the Archean to the Tertiary are discussed. --Auth.

3-2047. Konstantinov, M.M. THE METALLOGENY OF THE PACIFIC BELT: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 7, p. 4-11, 5 maps, pub. 1961, 8 refs.

The so-called Pacific Ocean metallogenic belt, covers the Asiatic and American coastal regions. S.S. Smirnov propounded the idea of the existence of 2 metallogenic zones in this belt, an internal zone rich in Cu and an external zone rich in Sn. The existence of these zones was connected with the geological configuration of Mesozoic-Cenozoic folded structures of all regions bordering the Pacific Ocean. Typical minerals for such folded structures were Cu, Ag, Au, Zn, Cd, Hg, Sn, Pb, As, Sb, Bi, S, Te. Some of these minerals belong to the Mesozoic, and others to the Cenozoic metallogenic epoch. Mesozoic metallogenesis is characterized by occurrence of W and Sn, large deposits of which are concentrated along the Asiatic coastal areas. The main reserves of Sb in China are also connected with the Mesozoic metallogenic epoch though an important part of it is also found in the Cenozoic structures. The Cenozoic metallogenic epoch is characterized by occurrence of Cu, Ag, Hg, Pb, Zn, and Mo, mainly in American coastal areas. The author further describes the regularity of the development of the folded rocks of the Pacific Ocean belt. These parallel more ancient ones, which means a gradual migration of orogenic zones from the Siberian, Chinese, and Australian platforms to the E. and toward the oceanic depression. Intensive folding periods were succeeded by other tectonic movements which led to a gradual sinking of certain parts of the Asian littoral. This sinking process corresponded in time to the elevating processes along the American coastal regions, and the edge of the American platform was first transformed into a geosynclinal region and then into a folded structure. S.S. Smirnov's theory of an external (American) Sn zone was found to be incorrect. No large Sn deposits have been discovered in America, and the large South American Sn-W deposit is due to local geological conditions. The author comes to the conclusion that the meaning of the expression "the Pacific Ocean ore-belt" must be modified. He proposes retention of this name only in relation to the ore belt associated with the development of Cenozoic folded formations. The zone of the Mesozoic fold formation observed only in E. Asia must be called the E. Asian ore belt.--From LC.

13. FUELS

See also: Geologic Maps 3-1752, 3-1753; Structural Geology 3-1799; Stratigraphy 3-1817.

3-2048. Gardner, Frank J. OIL STANDS TO GAIN FROM THE MOHOLE: Oil & Gas Jour., v. 59, no. 3, p. 119, map, Jan. 16, 1961.

If present plans to drill the Mohole in 12,000 ft. of ocean water are successful, then boundless new possibilities are apparent for oil exploration all over the world.--M. Russell.

3-2049. Martin, Rudolph. PRINCIPLES OF PALEOGEOMORPHOLOGY: Can. Mining & Metall. Bull., v. 53, no. 579, p. 529-538, 13 figs., July 1960, 27 refs.

Under the term "paleogeomorphology" are grouped together all geomorphological phenomena which are recognizable in subsurface geology. Since geomorphology is the science of the earth's relief features, paleogeomorphology is the science of buried relief features. Such features are of importance to the petroleum geologist whenever they lead to the trapping of hydrocarbons. In areas where these features abound - and western Canada certainly is such an area- paleogeomorphology ranks in importance with stratigraphy and structural geology as a hydrocarbon-finding tool.

Hydrocarbons may be trapped either directly or indirectly due to paleogeomorphological processes. Both types of traps may occur either below the morphological surface or above (against) it. Several examples of types of paleogeomorphological traps are given.

A new classification of geomorphological features is proposed, with a subdivision into 2 main groups, constructive and destructive geomorphic processes. Of the many geomorphic classifications, some are of greater interest to the petroleum geologist in western Canada than others. In the present paper the morphology of reefs and of buried erosional land forms are discussed in greater detail.

In dealing with the reefs of the Devonian Leduc formation in Alberta, it is found that several groups of reefs can be distinguished and that each group presents a separate set of morphological characteristics. The effects of erosion and weathering are exemplified mostly in the Devonian, Mississippian, and Jurassic of Alberta, Saskatchewan, and Manitoba. Hydrocarbon traps occur below the highs on the erosional surface as well as in sands laid down in the lows of that surface. The rules which govern the formation of ancient landscape forms are worked out, using an area in southeastern Saskatchewan as an example.--Auth.

3-2050. Gardner, Frank J. NEW X-RAY COMPUTER "FINGERPRINTS" ROCK SAMPLES: Oil & Gas Jour., v. 58, no. 51, p. 133, illus., Dec. 19, 1960.

The Gulf Oil Co. has developed an electronic device which identifies constituent minerals, their percentage occurrence, and correlates and prints a complete analysis of rock samples. It combines an X-ray analyzer and an IBM 704 computer to which has been fed the characteristics of 35 commonly observed minerals.--M. Russell.

3-2051. GEOLOGISTS URGED TO SEEK BETTER WELL SPACING: Oil & Gas Jour., v. 58, no. 44, p. 62-63, illus., Oct. 31, 1960.

Geologists are urged to take a more active interest in instigating proper well spacing from the very beginning of a new field. The money spent in drilling unnecessary wells could be used instead for geologic exploration to find new reserves.--M. Russell.

3-2052. Miller, George H. "RADIATION SURVEYS CAN FIND OIL": Oil & Gas Jour., v. 59, no. 7, p. 124-127, 3 maps, Feb. 13, 1961, 2 refs.

Radiation surveys depend on the phenomenon that gas leakages are greater over petroliferous accumulations. It is maintained that radiation surveys and related geochemical surveys are fast and economical and should be used as a reconnaissance method to be supplemented with subsurface gravity and seismic work.--M. Russell.

3-2053. Roy, Amalendu. THE INDUSTRY MAY SOON NEED A NEW APPROACH TO GEOPHYSICAL METHOD OF FINDING OIL: Oil & Gas Jour., v. 58, no. 45, p. 208-211, 2 figs., table, Nov. 7, 1960, 7 refs.

The search for petroleum has been based on either direct oil shows or indirect location of major structures. The first possibility exhausted itself soon enough and the second is fast dwindling. There are no standard geophysical methods that can spot stratigraphic traps in a routine fashion. Among the purely structural traps, geophysical methods can reliably locate only a small fraction of the total available, as for example anticlines of 5 to 10 m. closure. Promising or likely new methods lie in aerogravity surveys, geochemical prospecting, and radioactivity methods. Sandex, Loncolog, seismic, electric, and electromagnetic methods are also surveyed, but prospects for a breakthrough in them seem unlikely.--M. Russell.

3-2054. Shrewsbury, James B. TAKE ANOTHER LOOK AT THE SURFACE FOR CLUES TO STRATIGRAPHIC TRAPS: Oil & Gas Jour., v. 59, no. 2, p. 118-120, map, log, Jan. 9, 1961.

An analysis of the relation of the Illinois basin and thickness of the Chester series [Mississippian] to the environs is used to illustrate the point that detailed examination of surface rocks over wide areas will help in the discovery of stratigraphic oil traps.--M. Russell.

3-2055. Habermann, Ben. A STUDY OF THE CAPILLARY PRESSURE-HYDRODYNAMIC RELATIONSHIP TO SOIL [SIC] ACCUMULATION IN STRATIGRAPHIC TRAPS: Can. Mining & Metall. Bull., v. 53, no. 582, p. 811-817, 6 figs., 5 tables, Oct. 1960, 7 refs.

The object of the work described in this paper was to increase the understanding of the relation that capillary pressure of a rock, hydrodynamics, and accumulation of oil in stratigraphic traps have to one another. The hydrodynamic oil-water tilt equation is derived by considering the 2 vector gradients involved: 1) buoyancy of oil in water, and 2) hydraulic gradient.

Recent theories show the necessity for oil to have a continuous phase in the reservoir rock in order to migrate; this fact applies to hydrostatic as well as to hydrodynamic conditions. Hydrostatically, the displacement pressure of the rock determines the amount of oil that can be trapped behind a permeability barrier. If the buoyancy of oil in water exceeds the displacement pressure, oil will migrate updip; an oil trap will be formed where displacement pressure is greater.

In stratigraphic traps the pressure drop caused by moving water is positive when its direction is downdip, helping accumulation; and it is negative when its direction is updip, forcing the oil into the tighter section of the reservoir. Theoretically, provided we have data as: 1) the displacement pressure of an updip permeability pinchout, 2) density difference between the oil and water in place, and 3) the direction and magnitude of the hydrodynamic gradient (if any), the possible extent of a stratigraphic oil accumulation downdip can be predicted.

To test the above theory, sample cores from 3 wells in the Denver basin were analyzed, and the oil column that could be held under hydrostatic conditions was calculated. After the hydrodynamic influence was considered, the results were compared with actual field data.

The significant fact shown by this investigation is that the calculated oil column in one reservoir very closely approximates the actual extent of the oil column in a well. Also in accordance with the theory, the capillary pressure caused by the buoyancy of the oil column exceeded the measured displacement pressure on core samples from another productive field. For very tight shaly sand and questionable oil shows, the interpretation of data is very critical, as shown by experiments on core samples from a third field.--Auth.

3-2056. Bray, Ellis E., and Ernest D. Evans. DISTRIBUTION OF n-PARAFFINS AS A CLUE TO RECOGNITION OF SOURCE BEDS: Geochim. et Cosmochim. Acta, v. 22, no. 1, p. 2-15, 7 figs., 3 tables, Feb. 1961, 18 refs.

A preference for n-paraffins with odd numbers of C atoms is widespread in Recent sediments. Analyses of numerous Recent sediment samples indicate that molecules with odd numbers of C atoms predominate in the heavy n-paraffins for at least the first few thousand years after deposition. The depositional environments studied include a continental shelf, some ocean basins, bays, fresh-water lakes, a saline lake, and soils. In contrast, the heavy n-paraffins in a representative selection of crude oils are evenly distributed between molecules of even- and odd-C number.

Analyses of a limited number of postulated source rocks showed no preference in the heavy n-paraffins for molecules of either odd- or even-C number. Some shales and limestones ranging from Eocene to Mississippian in age have been examined for possible application of the n-paraffin distribution to recognition of source beds.--Auth.

3-2057. Erdman, J. Gordon. SOME CHEMICAL ASPECTS OF PETROLEUM GENESIS AS RELATED TO THE PROBLEM OF SOURCE BED RECOGNITION: Geochim. et Cosmochim. Acta, v. 22, no. 1, p. 16-36, 5 figs., 13 tables, Feb. 1961, 31 refs.

Source sediments of petroleum are defined as those rocks in which appreciable quantities of crude oil have been generated. The criterion for genesis of crude oil is the formation in appreciable quantities of all the major constituents, namely, the low molecular weight aromatic and aliphatic hydrocarbons, the higher molecular weight hydrocarbons and the asphaltics.

It has been indicated that in certain rocks a higher proportion of the organic matter initially deposited in the sediments is converted into constituents of petroleum. The major fractions of petroleum almost certainly are formed from particular classes of plant and animal compounds. Composition, or at least the relative abundance of these chemical precursors, varies throughout the plant and animal kingdoms. Thus, the environment, as it affects the ecology, would affect the composition of the source material. Whether other environmental factors enter by altering the course of the degradations of the chemical source material is at present unknown.

Finally, it is believed that the proportion of the organic material converted to petroleum in the rock is more significant than the absolute amount formed. In the freshly deposited sediments, the highly polar constituents of the organic fraction are preserved from loss during the early expulsion of water by adsorption on mineral constituents of the sediment. As functional groups are lost to form the weakly polar constituents of petroleum, the association with the mineral matter weakens. At the same time, however, attraction to the relatively hydrophobic surfaces of solid carbonaceous matter increases. The retentivity of the sediment during compaction for the constituents of petroleum thus becomes a function of the amount of solid carbonaceous material. Dynamically, the carbonaceous material will retard migration of the constituents of petroleum. If the amount of the latter is sufficiently high in proportion to the insoluble solid carbonaceous material, the process will tend merely to concentrate the constituents of petroleum until they break out of the fine-grained sediment. If the proportion of the migrating organic material is too small in proportion to the stationary carbonaceous material, migration will be too slow to permit the former to escape from the sediment. Thus, it is not unreasonable that rocks like the Anahuac shale of Texas with a relatively low total C content probably have been responsible for crude oil deposits in quantity, while the Green River oil shale and most coals, with a higher content of gaseous and liquid hydrocarbons and other petroleum constituents, apparently have failed to yield oil.

Recognition of source sediments of petroleum will not likely be accomplished through application of any single test. Rather, recognition of a rock as having been a prolific source of oil, or of varying smaller amounts, of none at all, will remain a matter of judgement. The ability to achieve diagnostic precision, however, should grow with an increasing understanding of the chemical reactions which plant and animal detritus undergo when buried in the earth.--From auth. concl.

3-2058. Hunt, John M. DISTRIBUTION OF HYDROCARBONS IN SEDIMENTARY ROCKS: Geochim. et Cosmochim. Acta, v. 22, no. 1, p. 37-49, 5 figs., 6 tables, Feb. 1961, 9 refs.

Free liquid and solid hydrocarbons comparable to those in petroleum are constituents of practically all sedimentary rocks. The quantities vary from a few parts per million in continental deposits to several thousand parts per million in bituminous marine shales. Associated with this oil are 2 other substances - a soluble asphalt, and an insoluble pyrobituminous material called kerogen.

There is no systematic change in the hydrocarbon content of sedimentary rocks with depth or age. The biggest variations seem to be between different formations and different facies of the same formation. Metamorphism appears to decrease the hydrocarbons and to alter the kerogen of a rock.

Comparisons of reservoir hydrocarbons with the hydrocarbons from their presumed source rocks show that the latter tend to contain a greater percentage of aromatic hydrocarbons.

Commercial accumulations of hydrocarbons in reservoir rock represent only a fraction of the total hydrocarbons estimated to exist in a finely disseminated form in practically all sedimentary rocks of marine origin.--Auth.

3-2059. Khalifeh, Y., and M.C. Louis. ÉTUDE DE LA MATIERE ORGANIQUE DANS LES ROCHES SEDIMENTAIRES [Study of Organic Matter in Sedimentary Rocks]: Geochim. et Cosmochim. Acta, v. 22, no. 1, p. 50-57, 5 figs., table, Feb. 1961, 4 refs.; text in French.

Although the mechanism of selective oxidation of organic material in sediments is not yet understood, we can however, by this method, establish some very clear differences concerning the origin of the organic material and its conditions of deposition.

The oxidation curves do not differentiate the marine deposits from the continental deposits. One sees, for example, a difference in the behavior of the marine deposits in a reducing environment (source rock) and in a lagoonal environment (St. Champ and Seefeld). The present muds present another manner of curve. On the other hand, the Rifle Ridge continental schist could be considered as source rock.

In summary, we obtain 3 types of oxidation curves: 1) ascending curve - characteristic of source rocks; 2) descending curve - characteristic of formations which have not yielded petroleum; 3) a practically horizontal curve - characteristic of present marine muds. There is still another changeable for the lagoonal formations.

If the proposed method does not show absolute proof that a sediment has functioned as source rock, it permits the discarding of those that have not been generators of petroleum, and among others, it indicates additional probabilities.

One can thus, in a given basin, select certain formations from which organic material can be calculated. One can then get an idea of the quantity of petroleum which they can provide. Such indications will explain without doubt why a known formation contains only traces of petroleum. It can also explain the concentration of oil in a certain part of a basin.--Auth. concl., translated by L. M. Dane.

3-2060. Meinschein, W.G. SIGNIFICANCE OF HYDROCARBONS IN SEDIMENTS AND PETROLEUM: Geochim. et Cosmochim. Acta, v. 22, no.1, p. 58-64, 11 figs., Feb. 1961, 12 refs.

Sediments and crude oils contain the same types of hydrocarbons. This analogy indicates that petroleum is derived from sedimentary organic matter. The close resemblance of hydrocarbons in sediments and crude oils to the products of living organisms indicate that compounds pass from living things into petroleum deposits without appreciable chemical change. Major transformations of organic matter into petroleum-like compounds do not appear to be an essential function of source beds. Neglecting bacterial modifications and rearrangement of unsaturated products that apparently occur shortly after deposition of plant and animal remains in sediments, the important processes in forming petroleum deposits are probably physical in nature. Sediments in general rather than unusual sediments are seemingly the true "source rocks" of petroleum.--Auth.

3-2061. Dean, James W., and Robert E. Lauth. FOUR CORNERS KEEPS LEAD IN PRODUCTION OF HELIUM GAS: Oil & Gas Jour., v. 59, no. 8, p. 194-199, 7 figs., Feb. 20, 1961, 6 refs.

The existence of significant accumulations of He in the Four Corners area [Utah, Colorado, Arizona, New Mexico] has been known for several decades. Pinta dome, northeastern Arizona, is the richest. The Pennsylvanian, Permian, and Triassic regional stratigraphy, structure, isopach data, and logging results are analyzed for evidence as to why this gas should be so concentrated here.--M. Russell.

3-2062. U. S. Bureau of Mines. A BIBLIOGRAPHY OF BUREAU OF MINES PUBLICATIONS DEALING WITH OIL SHALE AND SHALE OIL, 1917-1959. Compiled by M. K. Cowan: 25 p., Laramie, Wyoming, Laramie Petroleum Research Center, Jan. 1960.

The approximately 375 references are listed alphabetically by author under each year from 1917 through 1959.

3-2063. Hitchon, Brian, and others. EFFECT OF REGIONAL VARIATIONS OF CRUDE OIL AND RESERVOIR CHARACTERISTICS ON IN SITU COMBUSTION AND MISCIBLE-PHASE RECOVERY OF OIL IN WESTERN CANADA: Am. Assoc. Petroleum Geologists, Bull., v. 45, no. 3, p. 281-314, 18 figs., 10 tables, March 1961, 44 refs.

Of the more than 20 billion barrels (exclusive of crude oil in the McMurray formation [Lower Cretaceous]) of original in-place crude oil discovered in western Canada to date, it is expected that only about 4.75 billion barrels will be produced by primary methods and water flooding. Secondary recovery methods such as in situ combustion and miscible-phase flooding could result in the production of, approximately, an additional 8 billion barrels (exclusive of crude oil in the McMurray formation), and reviews of the pertinent factors concerning the technological application of both methods are presented. The comparatively simple regional variations in structure and thickness of the sediments in the western Canada sedimentary basin are noted, as well as the recent demonstration of parallel regional variations in the physical and chemical attributes of the formation fluids. Accordingly, each of 15 time-rock units is considered from the point of view of its areal distribution, the regional variations in thickness, stratigraphy, lithology, facies changes, and depth and characteristics of the petroliferous zones, and the regional variations in A.P.I. gravities of the crude oils. The regional applicability of the 2 secondary methods is then considered.

In general, it appeared that thermal methods were most suited to crude oils in the subcrop and Sweetgrass arch regions of the Upper Devonian, Mississippian, and lowermost Cretaceous sediments. For Jurassic crude oils, thermal methods appeared suitable throughout western Canada. A reverse combustion method was considered most applicable to the crude oil in the McMurray formation.

Conventional dispersed gas drives and enriched gas drives appeared to be suitable in most other regions for the other time-rock units, with high-pressure improved gas drives limited to those petroliferous zones deeper than about 5,000 ft. The miscible-slug technique appeared ideally applicable only to the Cardium formation [Cretaceous] crude oils.--Auth.

3-2064. 1960 OIL HUNTING GOOD IN SPOTS: Oil & Gas Jour., v. 59, no. 5, p. 145-150, 153, 6 figs., Jan. 30, 1961.

Exploration activities for 1960 were extensive in the Paradox basin, northern Rockies, Abo reef, Kingfisher, Alaska, deep Edwards, and E. Texas areas. The most significant results were that Devonian production at Lisbon disclosed a new horizon in the Paradox basin, and the tremendous worth of Mississippian production was reconfirmed.--M. Russell.

3-2065. Roberts, Wendell L., and Robert O. Vernon. FLORIDA - MORE EXTENSIVE DRILLING MIGHT UNCOVER BIG OIL AND GAS-PRODUCING AREAS: Oil & Gas Jour., v. 59, no. 11, p. 214-219, 3 figs., March 13, 1961, 6 refs.

Florida has a thick sedimentary section which contains oil shows and zones of porosity separated by impervious beds. The major structural features have been outlined from scattered well control. Two sedimentary provinces exist, the N. Gulf Coast sedimentary province containing clastic sediments and the Florida peninsula sedimentary province containing nonclastic carbonates and evaporites. Conditions favoring reef development are known to have existed in some areas of lower Cretaceous Sunniland deposition. Exploration efforts should not overlook the possibility of reef traps, porosity pinchouts, and traps associated with depositional structures within this zone. Below the Sunniland limestones other zones of porosity and oil shows are known to occur.--From auth. summ.

3-2066. Carpenter, G. L., and Howard Smith. OIL DEVELOPMENT AND PRODUCTION IN INDIANA DURING 1959: Indiana, Geol. Survey, Mineral Economics Ser. no. 6, 18 p., fig., 3 tables, 1960.

A review of oil development in Indiana during 1959 and a statistical report of production in Indiana by fields.--Auth.

3-2067. Kansas Geological Society. KANSAS OIL AND GAS FIELDS. VOLUME III, NORTHEASTERN KANSAS. With Special Contributions Covering SE Nebraska and NW Missouri. Editor: Graham R. Curtis: 220 p., maps, sec., logs., tables, [Wichita], 1960.

The third publication in this series. Vol. 1, published in 1956, covered fields in S.-central Kansas and Vol. 2, western Kansas (GeoScience Abstracts 1-3160). It was felt that the increased activity and new discoveries in NE. Kansas should be covered in order that interested parties, both in and out of Kansas, could better evaluate the province in terms of their own exploration programs. All fields could not be covered in one volume, but the book was designed so that a few additional papers could be added at a later date. This volume is a compilation of 31 fields in Kansas, 2 in Missouri, and 2 in Nebraska. To date, the 3 volumes have covered a total of 94 fields.

Fields are listed alphabetically by name. For each field the following information is given: location; method of exploration leading to discovery; discovery; geological conditions and nature of trap; thickness and lithology of reservoir rocks; thickness of productive zones; core analysis and/or electric log calculations; productive area and type drive; character of oil; character of gas; water production; completion treatment; marketing facilities; production history; required surface casing; average well cost.--A. C. Sangree.

3-2068. Merriam, Daniel F. **DRILLERS KEEP BUSY IN NORTHERN KANSAS: Oil & Gas Jour., v. 58, no. 42, p. 164-165, 168-170, 7 figs., table, Oct. 17, 1960, 5 refs.**

The Alma anticline in NE. Kansas is about 40 mi. long. Five fields have produced oil from local anticlinal structures in the Ordovician Viola limestone, the Silurian-Devonian Hunton group, and the Pennsylvanian Lansing and Kansas City groups. The stratigraphy and regional structure indicate that additional discoveries are likely.--M.Russell.

3-2069. Bennett, Frank O. **EUBANK MAY BE NEXT KANSAS OIL AND GAS-PRODUCING GIANT: Oil & Gas Jour., v. 58, no. 51, p. 134-138, 3 figs., Dec. 19, 1960.**

A review of recent discoveries and an analysis of the 7 Pennsylvanian-Mississippian producing formations in the Eubank area of the Hugoton field indicate that this area is likely to be a new giant among Kansas oil and gas producers. The formations are Toronto, Lansing-Kansas City, Marmaton, Cherokee, Morrow, Chester, and Meramec.--M. Russell.

3-2070. Kinard, John C. **GEOLOGISTS APPRAISE TULE CREEK AREA: Oil & Gas Jour., v. 59, no. 6, p. 172-173, 175, map, Feb. 6, 1961.**

The Poplar anticline area, Montana, is relatively untested although numerous structural and stratigraphic traps for oil and gas are present. The Murphy-Devonian discovery at Tule Creek, which gaged flows up to 46 bbl. of oil per hour, has revived this attractive geologic region. The present drilling program is expected to uncover a new oil province in the Williston basin.--Auth. summ.

3-2071. McNeal, Robert P. **HYDRODYNAMIC ENTRAPMENT OF OIL AND GAS IN BISTI FIELD, SAN JUAN COUNTY, NEW MEXICO: Am. Assoc. Petroleum Geologists, Bull., v. 45, no.3, p. 315-329, 9 figs., table, March 1961, 15 refs.**

The Bisti field, on the SW. flank of the San Juan basin, produces oil and gas from the Cretaceous Gallup sandstone. The accumulation is in a series of narrow permeability lenses totaling more than 30 mi. in length. The lenses are permeability developments in an epineritic facies. Updip from the epineritic facies is a transition zone of littoral and nearshore environmental deposits. A deltaic facies extends from the transition facies to the outcrops of the formation. Zones of sandstone developments can be traced from the epineritic facies through the transition zone to the deltaic facies. There is no structural closure or nosing in the field.

At the W. end of the field, the accumulation forms an oil column more than 365 ft. in height. The height of the oil column is sufficient to develop a capillary pressure of more than 52 lbs. per sq. in. at the updip edge of the accumulation. Analyses of the limited cores available indicate that the entry pressures, or threshold pressures, of the more permeable sandstones in the transition facies are in most places less than 22 lbs. per sq. in. The capillary pressure of the column of oil under hydrostatic conditions should be sufficient to cause much of the oil to migrate updip out of the permeability lenses. Favorable hydrodynamics is responsible for retaining the additional oil. A decrease in pressure causes a flow of water downdip across the permeability barrier to form a hydrodynamic trap sufficient to retain the oil accumulation. --Auth.

3-2072. Pitt, William D. **DIG DEEPER FOR OUACHITA RESERVES: Oil & Gas. Jour., v. 58, no. 46, p. 214-217, illus., 2 maps, Nov. 14, 1960, 7 refs.**

Discovery of gas in commercial quantity in the Potato Hills area of the Ouachita Mountains, Oklahoma, dramatizes the fact that Ordovician rocks of the Ouachita facies represent a good oil and gas objective, and that if rocks in the Potato Hills were metamorphosed, the metamorphism had no deleterious effect upon the gas pool. All Paleozoic formations in the area might locally be permeable enough, either in the form of a local sand zone or fracture porosity. One gas well produces from fractures in the Bigfort chert. The most promising reservoir rocks on outcrop are the Crystal Mountain sandstone and older rocks.--M.Russell.

3-2073. Planalp, Roger N. **HIGH DRILLING COSTS, VARIED GEOLOGY FAIL TO SLOW ARKOMA BASIN GROWTH: Oil & Gas Jour., v. 59, no. 1, p. 124-126, 128-129, map, chart, Jan. 2, 1961.**

The 2 main obstacles to successful exploration, drilling, and production of natural gas in the Arkoma basin, Oklahoma-NW. Arkansas, have been extremely variable geological conditions and high drilling costs. The geology is characterized by tightly cemented, resistant sandstones, moderate to steep dips, local anticlinal structures, and faulting. Most wells penetrate the Pennsylvanian Morrow formation and terminate in the Mississippian Pitkin limestone. --M. Russell.

3-2074. Pinkley, George R. **SOUTHWEST TEXAS EXPLORATION CENTERS ON EDWARDS TREND: Oil & Gas Jour., v. 58, no. 47, p. 262, 265-266, Nov. 21, 1960; no. 48, p. 112, 115, 117-119, Nov. 28, 1960, 2 maps.**

Two recent discoveries of oil at depths greater than 10,000 ft. has greatly renewed interest in the deep Edwards trend of SW. Texas. The regional geology is such that the principal problem in exploration is the uncovering of the older Cretaceous surface and mapping its paleogeography. The results of seismic studies and drilling programs are reviewed, and the reservoir conditions, distribution of salt domes, the stratigraphic section, and economics of the area are summarized. Twenty-two specific fields have so far been discovered.--M. Russell.

3-2075. Budd, Harrell. **TEAMWORK IS KEY TO SUCCESS IN TRACKING DOWN LISBON OIL: Oil &**

Gas Jour., v. 59, no. 9, p. 154-156, 2 maps, Feb. 27, 1961.

Discovery of Devonian and Mississippian oil and gas production in the Lisbon field, Utah, shows that despite low porosities and permeabilities, the thick fractured pay sections and high reservoir pressures point to a favorable reserve picture. Success was reached by a team effort combining land, engineering, geophysics, and geology.--M. Russell.

3-2076. Wood, George R. JAMAICA EXPLORATION TO BE UNHURRIED, THOROUGH: Oil & Gas Jour., v. 59, no. 5, p. 222-224, 227, 2 maps, table, Jan. 30, 1961.

There has been little exploration for oil in Jamaica in the past because it was widely held that there were only thin sections of Tertiary and Cretaceous rocks overlying volcanics. While this is true in the SW. part, thick Cretaceous sections have been found in the eastern third which will be further explored.--M. Russell.

3-2077. BRAZILIAN OIL PICTURE: HOPELESS, SAYS TOPFLIGHT U.S. GEOLOGIST: Oil & Gas Jour., v. 59, no. 2, p. 58-59, Jan. 9, 1961.

A report by Walter Link and 13 other geologists to the board of directors of Petroleo Brasilero, which included a rating of Brazil's 12 major sedimentary basins, concluded that although the country has one of the largest sedimentary basins in the world, it probably will never produce enough oil to meet its own needs unless new oil-discovery tools are developed.--M. Russell.

3-2078. JORDAN NEEDS MORE WILDCATS: Oil & Gas Jour., v. 58, no. 50, p. 168-170, 5 illus. map, Dec. 12, 1960.

Jordan is one of only 2 countries in the Middle East which lack oil fields. Its regional geology is such that oil finds are likely. Exploration has not been lacking, but increased wildcat drilling should be encouraged.--M. Russell.

3-2079. SOVIETS CLAIM HUGE RESERVES IN DESERT AREA: Oil & Gas Jour., v. 58, no. 44, p. 71-72, map, Oct. 31, 1960.

"Third Baku" is the title given a vast arid region in Turkmenia and Uzbekistan E. of the Caspian Sea. The Russians are claiming a gas field rivaling the world's largest and oil reserves comparable to Kuwait and Saudi Arabia. Soviet geologists characterize the Cheleken structure, one of the areas most promising, as "a smashed plate" because the oil-bearing structures consist of "many dozens of blocks isolated from each other." --M. Russell.

3-2080. McCaslin, John C. OIL INTEREST FLARES THROUGHOUT AFRICA AS STRIKES OPEN NEW AREAS: Oil & Gas Jour., v. 58, no. 41, p. 286-290, 3 illus., 2 maps, Oct. 10, 1960.

Oil exploration, drilling, and production activity in Africa is increasing. A summary of geologic conditions, current activity, and oil potential includes 9 producing countries and an additional 9 countries where wells have been drilled.--M. Russell.

3-2081. de Mohrenschildt, George. NEARBY PRODUCTION HINTS TOGOLAND'S BASINS MAY JOIN GROWING LIST OF NEW OIL PROVINCES: Oil & Gas Jour., v.58, no. 43, p.166-167, 2 figs., Oct. 24, 1960.

Stratigraphic and tectonic relations in Togoland, W. Africa, with the fact of active production in related features in nearby areas, indicates a promising new area for exploration. Interest should center on the Paleozoic Voltaian basin in the N. and the Tertiary Togoland-Dahomey coastal basin.--M. Russell.

3-2082. Schopf, James M. FIELD DESCRIPTION AND SAMPLING OF COAL BEDS: U.S. Geol. Survey, Bull. 1111-B, p. 25-70, fig., 22 pls. (3 in pocket), 1960, 22 refs.

Field procedures used in describing and sampling coal deposits should be uniform, and the acquired data should be as quantitative and complete as possible. Field data are the basis for laboratory studies and all conclusions drawn from fieldwork.

The lithologic layers (ingredients) whose alternation causes the banding observed in most coal beds should be identified in the field as vitrain (previtrain in lignite), fusain, attrital coal, impure coal, and partings. Other terms, no matter how nearly synonymous, should not be used in field descriptions. Vitrain bands generally have brilliant luster, vitreous appearance, conchoidal fracture and are closely cleated. Previtrain in lignite lacks these properties but is tougher and smoother textured than other ingredients. Fusain resembles charcoal, is soft and friable unless mineralized, is dull and occurs in chips or thin layers. Attrital coal is the matrix between the other ingredients and is intermediate between them but highly variable in luster, friability and cleat. It includes the streaks resembling vitrain and fusain that are thinner than half a millimeter. Impure coal and partings should be described fully by using standard geologic terms; local or common nondescriptive terms (for example, bone, rash) are inadequate. Notation of relative hardness is important.

Nonbanded coal is uncommon but may form entire beds or be bedded with banded coal. It is formed of sorted plant debris and is thus uniform in texture, compact, and massive. Its megascopic appearance is controlled only by particle size; its classification as boghead or cannel requires microscopy.

In the field a clean, unweathered coal face should be divided for descriptive purposes into units of uniform character. The thickness of the layers should be recorded in millimeters (one twenty-fifth of an inch), and the thickness of principal units and the over-all thickness of the bed should be recorded in feet and inches. Recommended quantitative terms for both thickness and concentration of each lithologic type within each unit should be used in addition to descriptions of luster, texture, and fracture. The spacing and orientation of cleat (vertical joint planes), secondary mineralization, impure layers and partings, and roof and floor rock should be measured and described in standard geologic terms. Although field observations are necessarily made under many different conditions, later comparisons and interpretations should be as uniform as possible. This requires that field notation of conditions of observation (favorable, generalized, or unfavorable) be made.

The type of coal sample taken depends on the laboratory determinations desired. Mixed samples (channel samples) representative of entire bed thickness are standard for ordinary chemical analyses and suitable for some microfossil studies. Individual block samples that together represent the entire bed are useful for nearly any type of chemical, petrologic, or plant fossil study, but a monolithic column sample of the entire bed is superior. Every type of sample, including cores, must be vigorously guarded against moisture loss if the samples are to be used for microscopic study or for chemical analysis. Moisture is not an important consideration in samples obtained solely for microfossils. Cores should be handled as little as possible in the field. Directions for taking samples and for construction of suitable core boxes are given.

Trends of variation in the properties of coal beds that are measured in the field or in the laboratory are best presented by means of maps on which contours are shown for the particular property under consideration. Some of the properties are the thickness of the entire coal bed or correlative parts of it, the interval between coal beds, overburden thickness, concentration of vitrain or other petrologic type, spacing of cleat, secondary mineralization, any of the results of chemical analysis, C or other ratios. --Auth.

3-2083. Pearson, G. Raymond. THE CLOVER BAR COAL ZONE, EDMONTON - MORINVILLE DISTRICT, ALBERTA: Research Council Alberta, Prelim. Rept. 61-1, 26 p., 3 maps (2 in pocket), secs., 2 tables, 1961, 17 refs.

Continued increase in the power demand of western Canada will most economically be met by a return to coal as fuel for future thermal power installations. This report, summarizing the 1960 field season, is the third in a survey series undertaken by the Research Council of Alberta to provide an inventory of the Province's coal resources that are suitable for recovery by cheap large-scale stripping methods.

In the Edmonton district (53°30'N. 113°30'W.), 10 superimposed relatively flat-lying coal zones have been described at the base of the Edmonton formation of Upper Cretaceous (Maestrichtian) age. The 1960 investigation concentrated on the most promising of these, the No. 4 or Clover Bar zone, and traced it, chiefly by drill-hole and electrolog studies, for over 30 mi. NW. along strike and up to 6 mi. downdip (SW.) from the outcrop. The zone everywhere contains one or more coal seams which vary greatly in thickness, making accurate estimation of the reserves hazardous; nevertheless a considerable area N. of Edmonton in the region of Carbondale was shown to be underlain by coal exceeding 5 ft. in thickness and with a cover of less than 75 ft. In this area, reserves suitable for strip-mining were tentatively estimated at a minimum of 50 million tons.--J. D. Campbell.

3-2084. Pye, Willard D. PRELIMINARY PETROGRAPHIC STUDY OF SOME CRETACEOUS COALS IN ARIZONA: Arizona Geol. Soc., Digest, v. 3, p. 109-110, 1960, 7 refs.

For the purpose of better evaluating the coal deposits of Arizona a petrographic study of them has been started. Preliminary results of study are given for the Dakota coal, Mesa Verde coal, and Deer Creek coal basin, including some proximate analyses.--M. Russell.

3-2085. Arkhangelsky, A.I. MESOZOIC COAL MEASURES ON THE EASTERN SLOPE OF THE MALYY (LITTLE) KHINGAN RANGE AND ADJACENT PROVINCES: Akad. Nauk SSSR, Izvestiya, Geol. Ser., in translation, 1959, no. 4, p. 64-72, map, table, pub. 1960, 15 refs.

The coal measures of the Birsk coal field and Khegan coal region belong to the Upper Jurassic and Lower Cretaceous and are contemporaneous with the Zeya and Bureya basins' coal measures.

E. of the Malyy Khingan range and in adjacent areas of the western Amur region, 3 upper Mesozoic phases of coal accumulation have been recognized. By their structural features and history of tectonic development, coal basins in this area are divided into 3 types: 1) platform; 2) geosynclinal; 3) genetically related to structural forms akin to foredeeps.

The Amur-Sungari trough, specifically along the lower courses of Bidzhan and Sungari, may be recommended as the prime objective of geophysical, geologic, and drilling work for the purpose of discovering new deposits of coke coal of the geosynclinal type. The search for new Upper Cretaceous and Tertiary brown coal basins within the western Amur region and adjacent provinces of Manchuria is justified in the area of distribution of platform structures.--From auth. summ.

14. ENGINEERING GEOLOGY

3-2086. Wood, Lawrence C. ENGINEERING GEOLOGY DATA: Am. Geol. Inst., AGI Data Sheet 24, 2 p. in GeoTimes, v. 5, no. 7, p. 29-30, 2 figs., 2 tables, Apr. 1961, 4 refs.; also pub. separately.

In 2 parts: pt. 1, Physical Properties of Rocks, lists data on 16 characteristics of 40 common rock types of significance in engineering practice; pt. 2, The Use of Mohr's Circle in Geology, shows how a nomograph can be used in problems involving normal and shear stresses.--M. Russell.

3-2087. Neilson, James M. THE TEACHING AND PRACTICE OF ENGINEERING GEOLOGY: Can. Mining & Metall. Bull., v. 53, no. 584, p. 965-969, 4 tables, Dec. 1960, 10 refs.

A review of the various aspects of the field of engineering geology concludes with a comparison of the development and teaching of this relatively new professional specialization in the United States and Canada. The writer prefers to restrict the designation "engineering geology" to geological applications in the field of civil engineering and its related branches, and to differentiate it from geological engineering. The need for a sound geological training is stressed. Such training will likely require at least 1 and perhaps 2 years of graduate study.--P. R. Eakins.

3-2088. Banks, Harvey O. THE RELATIONSHIP OF GEOLOGISTS & ENGINEERS IN PLANNING PUBLIC WORKS PROJECTS: GeoTimes, v. 5, no. 7, p. 16-17, 32-33, Apr. 1961.

The recognition of engineering geology as a profession has been long in coming but is now well established. The role of the engineering geologist is exemplified by projects carried out by the California Dept. of Water Resources, one involving the selection of the route for an aqueduct to convey Feather River Project water to Southern California, and another involving the selection of a tunnel site through the

Coast Ranges near Pacheco Pass. Close cooperation between geologists, civil engineers, and other specialists is essential.--M. Russell.

3-2089. Hughes, H. Edwin. MUSKEG AREA ACCESS STUDIES USING AERIAL PHOTOGRAPHS: Can. Mining & Metall. Bull., v. 53, no. 579, p. 515-523, table, July 1960, 17 refs.

Aerial photographs are a valuable source of terrain and topographic information on mineral soils and muskegs. Assisted by representative observations on the ground, air photo interpretation facilitates selection and analysis of new road locations on either type of terrain.

Muskeg is usually the major problem in route selection and road construction in remote areas. Some of the developments in muskeg "technology" are outlined in this paper, but many of the engineering characteristics of peats are not yet well enough understood for quantitative evaluation.

In some areas it is impossible to avoid muskeg - or it may be economically practical to cross, rather than build extra miles of road around it. Some muskeg may be encountered in the interest of maintaining reasonable alignment. Considerations of the costs and suitability of various muskeg road construction methods significantly affect route selection.

Informed engineering judgment is instrumental in selection of the most economic access route, meeting the desired objectives. Many factors - some incompletely defined - must be weighed.

Access to the Milligan Creek oil field of NE. British Columbia has been subjected to detailed study and a fairly direct route selected and proven out on the ground. This route will be of value to several companies, at less cost to any one operator.--Auth.

3-2090. McFarlane, H. W. THE BEECHWOOD EARTH-FILL DAM (In: Canadian Soil Mechanics Conference. 13th, Sept. 1959. Proceedings: Natl. Research Council Canada, Associate Comm. Soil & Snow Mechanics, Tech. Memo. no. 63, p. 29-38, 1960) 3 refs.

The eastern 500 ft. of the 1,750 ft.-long dam across the St. John River, New Brunswick, retaining water for power generation in the adjacent 90,000 h.p. power house, under a head of 60 ft., is a rolled earth-fill structure. Local bedrock is argillite, overlain with river terrace gravels. An extensive grouting program, necessitated by fissuring of the argillite discovered after de-watering, seriously delayed the construction schedule for the placing of glacial till and gravel in the earth dam. Fall rains added to construction problems. Eventually an aggregate dryer was obtained from an asphalt plant, and all soil too wet to place in its natural condition was put through the dryer, which reduced moisture contents from 4 to 8 %. The fill was successfully completed late in Nov. [1958?] following the first snowfalls and temperatures as low as 15°F.--R. F. Legget.

3-2091. U.S. Bureau of Reclamation. TECHNICAL RECORD OF DESIGN AND CONSTRUCTION. PALISADES DAM AND POWERPLANT, CONSTRUCTED 1951-1957, PALISADES PROJECT, IDAHO: 535 p., 188 figs. incl. illus., maps, secs., diags, graphs, tables, Denver, Colorado, Dec. 1960.

This report is divided into 3 parts. Pt. 1 is devoted to general planning, historical information, a description of the features, a summary of costs, and geology. Pt. 2 contains 6 chapters covering the design of the various features and their components. Pt. 3 contains 1 chapter on contract administration and 4 chapters comprising a concise narration of construction operations and equipment installation.

Palisades dam and reservoir are situated in the upper Snake River valley in eastern Idaho. The region is one of moderate-to-high relief in which both the topographic and geologic structure of the mountain ranges and ridges show a NW.-SE. linearity roughly paralleling the course of the Snake River in this area. To the SE., the ridges merge with the mountainous terrain along the Wyoming-Idaho border; to the NW., they decrease in elevation and are buried beneath the flat-lying lavas and sediments of the Snake River plain.

The reservoir basin - 2 1/2 to 3 mi. wide and 18 mi. long - lies in a deep erosional valley in a region of disturbed sedimentary and igneous rocks of various ages. The major rock types include limestone, shale, sandstone, compacted clay-silt-sand-gravel beds, andesite, and conglomerate.

The several groups of strata are separated by unconformities representing periods in which the region was deformed and subjected to extensive erosion. Thus, a clay-silt-sand-gravel group of beds (possibly early Tertiary) was deposited upon the eroded surface of an older deformed group of limestone, shale, and sandstone beds (Paleozoic and Mesozoic). The younger sedimentary series was tilted down towards the NE. at angles up to 45°, leveled by erosion, and capped by a thick series of conglomerate beds. Near the end of the conglomerate deposition, irregular to sill-like masses of andesite were intruded into the tilted sedimentary series; further igneous activity yielded deposits of volcanic ash and flows of basalt and rhyolite. In the recent phases of the geologic history, the Snake River removed much of the overlying deposits and cut into the tilted clay-silt-sand-gravel beds and andesite sills. One such sill makes up the left abutment of the damsite, and the overlying sedimentary strata constitute the foundation and right abutment.

The floor of the reservoir is a rather flat plain; overburden consists of horizontal layers and lenses of river-deposited silt, sand, gravel and cobbles. The overburden ranges from 5 to 60 ft. thick and is believed to be underlain predominantly by the tilted sequence of clay-silt-sand-gravel beds which constitute the foundation of the dam. The left side of the reservoir is characterized chiefly by the faulted and disturbed older sedimentary sequence and the right side by the conglomerate and younger sedimentary sequence. High ground-water levels on the valley sides and generally tight bedrock strata indicate that the reservoir will be tight.--From foreword & p. 9.

3-2092. Winslow, John D. PRELIMINARY ENGINEERING GEOLOGY REPORT OF DAM SITES ON THE EAST FORK OF THE MUSCATATUCK RIVER IN SCOTT, JENNINGS, AND JEFFERSON COUNTIES, INDIANA: Indiana, Geol. Survey, Rept. Prog. no. 20, 30 p., 3 figs., 5 pls., 3 tables, 1960.

Preliminary engineering geology investigations have been made of 4 proposed dam sites and their reservoir areas in the valley of the East Fork of the Muscatatuck River and its tributaries, Big Camp and Big Graham creeks, in northern Scott County, southern Jennings County, and western Jefferson County. In this report the geologic column of the area has been divided, according to engineering characteristics, into 5 units. The bedrock consists of (in ascending order) unit 1, the Osgood formation and the Laurel limestone of Silurian age; unit 2, the Waldron shale and the Louisville limestone of Silurian age and the Geneva dolomite and the Jeffersonville limestone of Devonian age; unit 3, the North Vernon limestone of Devonian age; and unit 4, the Devonian portion of the New Albany shale. These rocks are overlain at most places by unit 5, the unconsolidated materials that range in character from red residual limestone soils to glacial till.

The bedrock formations stratigraphically below the North Vernon limestone (units 1 and 2) are essentially sound rock and offer few problems to dam and reservoir construction, except the possibility of a small amount of leakage. The Jeffersonville limestone (the top formation of unit 2) includes a gray limestone bed that contains a few solution channels, but otherwise it is sound rock. Most of the solution channels and sinkholes in the area have been formed in the North Vernon limestone (unit 3), and serious leakage from the reservoir probably would occur through this formation if it were not extensively grouted. The New Albany shale (unit 4) weathers quickly where it is exposed at the surface, and spillways on the New Albany shale must be designed to prevent the rapid erosion of the shale under the attack of running water. The red residual limestone soils (of unit 5) have high liquid limits, but these materials would make a satisfactory impermeable clay core of an earth dam. The other unconsolidated materials (glacial till, outwash silt and sand, and loess) overlying the bedrock are thin but sufficient in quantity to provide fill material for earth dams. Quarries could be opened in the limestone formations at any of the dam sites to supply concrete aggregate and fill material.--Auth.

3-2093. Jensen, Willard C. TIMBER PILES IN PERMAFROST AT ALASKAN RADAR STATION: Am. Soc. Civil Engineers, Soil Mech. & Found. Div., Jour., v. 87, no. SM1, pt. 1, p. 15-27, 12 figs., table, Feb. 1961, 5 refs.

Timber piles provide stable foundation in permafrost for a large U. S. Air Force "composite type" building at Kotzebue, Alaska. Pile load-deflection tests and soil temperature investigations performed during and after construction contributed valuable field data on point bearing support, pile deflections, slurry-pile adfreeze strengths, subgrade thermal changes and slurry freeze-back time by a natural or mechanical method.--Auth.

3-2094. Brawner, C. O. THE LANDSLIDE PROBLEM IN B. C. HIGHWAY CONSTRUCTION (In: Canadian Soil Mechanics Conference. 13th, Sept. 1959. Proceedings: Natl. Research Council Canada, Associate Comm. Soil & Snow Mechanics, Tech. Memo. no. 63, p. 45-60, 2 tables, 1960) 4 refs.

Two million dollars are spent on the average every year in the province of British Columbia for landslide remedial works. Location of many highways in major river valleys through the mountains results in much highway construction over alluvial soils. River-deposited silts have been the cause of much trouble. High snowfall in the mountains and consequent heavy spring runoff are further complications. Drainage, by means of perforated pipes placed in specially drilled holes, or through drainage tunnels in extreme cases, is a major remedial approach.--R. F. Legget.

See also GeoScience Abstracts 3-657.

3-2095. SOVIET BARES DEATH OF 145 IN MUD SLIDE: New York Times, v. 110, no. 37,688, p. 1, col. 7, p. 3, col. 6-8, map, Apr. 1, 1961.

Saturated silt, whipped by wind over an earthen dam and causing its collapse, flooded a populated ravine in the outskirts of Kiev, in the Soviet Ukraine, on March 13, killing 145 persons, injuring 143, washing away 22 houses, and trapping streetcars and buses.--M. Russell.

3-2096. Cameron, H. L. THE GEOLOGY OF THE ATLANTIC PROVINCES AND ITS EFFECT ON ENGINEERING CONSTRUCTION (In: Canadian Soil Mechanics Conference. 13th, Sept. 1959. Proceedings: Natl. Research Council Canada, Associate Comm. Soil & Snow Mechanics, Tech. Memo. no. 63, p. 3-12, illus., map, 1960)

Rocks from Precambrian to Triassic age are found in Canada's Atlantic provinces. Relative hardness and resistance to deterioration of the 2 main groups exposed determine local topography. Surface deposits are all glacial soils. Changes in sea level in postglacial time have contributed to some local soil features that have been employed to advantage in engineering construction. Glacial features such as eskers provide widespread supplies of useful building material, but supplies of rock for rock-fill structures have sometimes been more difficult to find than expected because of local geological factors such as faulting.--R. F. Legget.

15. MISCELLANEOUS

3-2097. Diaz, Albert James, ed. GUIDE TO MICROFORMS IN PRINT, 1961: 72 p., Washington, D.C., Microcard Editions, 1961.

The guide lists or refers to all that is available in microform from U. S. commercial publishers. Titles or projects of some noncommercial publishers are included. Theses and dissertations are not listed. Geologic material is included but not listed separately. There are approximately 10,000 entries filed alphabetically. Books and sets are listed by author or editor; journals are listed by title. Price of the work, its publisher, and the microform used to reproduce it are indicated.--M. Russell.

3-2098. Research Council of Alberta. FORTY-FIRST ANNUAL REPORT, 1960: Its: Rept. no. 80, 55 p., illus., maps, 1961, refs.

The Earth Sciences Branch through the work of the Groundwater Division has added to general knowledge of ground-water conditions and was able to provide information that was helpful in meeting several serious water-shortage situations. Several important bedrock channels have been located, and a test drilling program in terrace gravels of certain rivers in the Peace River region indicated the presence of large quantities of water at some points. A memoir has been published on the Milk River sandstone - an extensive subsurfaced aquifer that serves various communities and many farms in southern Alberta; recommendations are made for development and conservation of this important water supply.

The Geology Division has completed mapping of surficial deposits in the Crossfield, Provost, Czar, Redwater, and Morinville districts. A comprehensive program involves study of the fossil content, distribution, and physical make-up of Cretaceous rocks. Other projects include the study of Fe deposits, examination of a gypsum deposit at Mount Head and preparation of a report on the 4 known gypsum deposits in Alberta, and work on the beneficiation of surface sands.

The reconnaissance soil survey of the Hines Creek map sheet was completed and mapping of adjacent sheets checked prior to publication of reports. The exploratory helicopter soil survey covered some 10 million acres in the northwestern part of the province. Glacial geological information was obtained at the same time on this remote area. The Soils Division cooperated in studies on forest site classification and the irrigation of solonetzic soils.

The over-all cooperative Highway Research program was increased in scope, and Council's Highway Research section strengthened. The program involves a number of projects of special concern to the Provincial Department of Highways, with the major fields of interest being pavement design, materials and soils, highway structures, and hydraulic studies. The detailed studies involve laboratory and field aspects with such typical projects as relative performance of the investigational concrete pavement sections of the Trans-Canada Highway; low temperature strength properties of portland cement concerete mixtures; soil cement pavement construction and design with reference to load bearing capacity; clay properties as affected by adsorbed cations with reference to special landslide conditions; over-all examination of field moisture conditions, and preparation of soil maps adapted from published soil survey reports for engineering use.--From summ., p. 2-3.

3-2099. Ontario, Dept. of Mines. SIXTY-EIGHTH ANNUAL REPORT...1959: Its: Ann. Rept., v. 68, pt. 1 and 2, graphs, tables, pub. 1960.

The report is issued in 2 parts. Pt. 1 contains 1) Statistical Review of the Mineral Industry for 1958, by T. J. Kelly; 2) Provincial Assay Office, 1958, by D. A. Moddle; 3) Mining Accidents in 1958, by the Staff of Mines Inspection Branch; 4) Classes for Prospectors, 1958-59, by W. D. Harding. Pt. 2 contains Mining Operations in 1958, compiled by the Staff of the Mines Inspection Branch. It deals with asbestos, Cu, Cu-Pb-Zn, fluorspar, Au, gypsum, Fe, Mg, nepheline syenite, Ni and Cu, Nb, quartz crystals, salt, Au and Co, talc, U, metallurgical works.--A. C. Sangree.

3-2100. Ontario, Fuel Board. SIXTH ANNUAL REPORT...1959: 105 p., map, 13 tables, Toronto, 1960.

The report consists of 4 parts: 1) Natural Gas Industry in 1959; 2) Oil Wells and Production in 1959; 3) Exploration and Drilling; 4) Logs of Wells Completed in 1959. Leasing and drilling declined slightly in 1959; the number of well completions was 310 compared with 353 in 1958. Production of oil increased by 28.7%, and the production of gas by 4.3%.--A. C. Sangree.

3-2101. Carnegie Institution of Washington. ANNUAL REPORT OF THE DIRECTOR OF THE GEOPHYSICAL LABORATORY, 1959-1960: Its: Geophys. Lab., Paper no. 1340, 187 p., 77 figs., 4 pls., 19 tables, 1960, approx. 165 refs.

A summary of research done at the Geophysical Laboratory in the following fields: minerals of the mantle; phase equilibria in silicate and sulfide systems; ore minerals; iron meteorites; geothermal calculations; ages of rocks and minerals; biogeochemistry of stable isotopes of C; correlation in closed tables; crystallography.--A. C. Sangree.

3-2102. Missouri, Division of Geological Survey and Water Resources. SEVENTH BIENNIAL REPORT...COVERING PERIOD JULY 1, 1958 TO JUNE 30, 1960: 57 p., 3 figs., tables, 1960.

3-2103. Oregon, Dept. of Geology and Mineral Industries. TWELFTH BIENNIAL REPORT, 1958-1960: Its: Bull. 51, 13 p., illus., maps, graph, tables, 1960.

This report covers the period July 1, 1958, through June 30, 1960. It deals with Oregon's mineral production and industry, active mines, mineral and metallurgical plants, oil and gas drillings, relation of the Department to the mineral industry, Departmental projects and organization.--A. C. Sangree.

3-2104. Ray, Richard G. AERIAL PHOTOGRAPHS IN GEOLOGIC INTERPRETATION AND MAPPING: U.S. Geol. Survey, Prof. Paper 373, 230 p., 116 figs. incl. illus., maps, secs., diags., graphs, 1960, 139 refs.

Aerial photographs today are widely used to obtain both qualitative and quantitative geologic information; vertical aerial photographs are used almost to the exclusion of other types. Techniques and procedures described herein relate primarily to vertical photography.

Geologic interpretation of aerial photographs is based on the fundamental recognition elements of photographic tone, color, texture, pattern, relation of associated features, shape and size. The scale of photographs, as well as the vertical exaggeration that is present in most stereoscopic models, also are significant in photointerpretation.

The amount of geologic information that may be obtained from aerial photographs is primarily dependent on the type of terrain (igneous, metamorphic or sedimentary), climatic environment, and stage of the geomorphic cycle. Because features are more readily recognized where strong differences exist in the erosional resistance of adjacent rocks, sedimentary terrain may be expected to yield the greatest amount of information from aerial photographs. Metamorphic terrain may yield the least information because metamorphic processes tend to destroy differences that may have existed in the unmetamorphosed rocks. Combinations of criteria such as photographic tone, texture, pattern, and vertical exaggeration permit inferences as to rock type and geologic structure, which are important in petroleum exploration, ore deposits search, and engineering geology.

In petroleum exploration aerial photographs provide a wealth of information primarily with regard to potential structural traps. Folds commonly may be interpreted from a study of strike and dip of bedding and from stream patterns; anomalous stream characteristics, such as stream deflections, may suggest subsurface structures. The variety of photo recognition criteria that suggests faults permits aerial photographs to be of particular use in many or deposits studies. Analysis of soil patterns yields information regarding permeability of the surficial materials that are a concern of the engineering geologist.

The instruments used for viewing photographs, measuring geologic features, and compiling geologic maps range from simple stereoscopes and stereometers, or measuring bars, to complex double-projection instruments such as the multiplex or Kelsh plotter. Some instruments require the use of paper prints; others require the use of glass-plate diapositives. Measuring devices primarily provide spot heights or differences in altitudes; these quantitative data may be geologically significant in measurement of stratigraphic thickness and dip of beds and in structure contouring. Accuracy of vertical measurements is related fundamentally to the scale of photography and the instruments used for making measurements. In general, accuracy of measurement is greater when large-scale photographs are used and when double-projection instruments rather than simple parallax bars are employed.--Auth.

3-2105. Farquhar, Oswald C. THE GEOLOGIST [SIC] ASSOCIATION OF GREAT BRITAIN: GeoTimes, v. 5, no. 7, p. 12-13, 34-35, Apr. 1961.

The Geologists' Association of Great Britain was started, and is still maintained, primarily for amateurs interested in the earth sciences; it currently has about 2,100 members. The Association's history, publications, field trip activities, organization, and membership are described.--M. Russell.

3-2106. American Society of Limnology and Oceanography, Committee on Education and Recruitment. EDUCATION AND RECRUITMENT OF OCEANOGRAPHERS IN THE UNITED STATES: Limnology & Oceanography, v. 6, supp., 23 p., 2 graphs, 4 tables, Aug. 1960.

There are approximately 1,300 active oceanographers in the 24 leading U. S. oceanographic institutions; 137 are engaged in geological oceanography. Recruitment is barely sufficient to staff existing programs. The greatest shortage is of physical oceanographers. Opportunities, employment outlook, and training facilities in oceanography are reviewed. A broad program of recruitment, expansion of educational facilities, and increased financial support for teachers, students, facilities, and vessels in recommended.--M. Russell.

3-2107. AAPG SETS OUT TO DIAGNOSE GEOLOGY'S ILLS: Oil & Gas Jour., v. 58, no. 49, p. 80-81, illus., Dec. 5, 1960.

A committee of the American Association of Petroleum Geologists is making a survey of teachers and employers of geologists to find out exactly what is wrong, how long the problem will last, and outline a plan to brake unemployment in the profession, fend off any shortage of earth scientists in the future, swing teaching programs to meet industry's needs, and make sure the geologist is fairly treated by employers.--M. Russell.

3-2108. TROUBLE AHEAD IN THE SHAPE OF AN EARTH-SCIENTIST SHORTAGE: Oil & Gas Jour., v. 59, no. 15, p. 153, port., Apr. 10, 1961.

A 13% drop in total enrollment in geology and geophysics students in 1960 is but one of several signs that a future shortage of geologists will hamper the oil industry unless it takes steps now to convince the public that the oil industry has a bright future and to provide geologists and geophysicists greater job security than heretofore.--M. Russell.

3-2109. POLL SHOWS MOST GEOPHYSICISTS WORKING: Oil & Gas Jour., v. 59, no. 10, p. 85, March 6, 1961.

Apparently most geophysicists still have full-time jobs despite cutbacks. A survey of the membership of the Society of Exploration Geophysicists shows only 66 out of 3,900 who answered were hunting a job.--M. Russell.

3-2110. Harshbarger, John W., and Terah L. Smiley. UTILIZATION OF ARID LANDS PROJECT (GENERAL STATEMENT): Arizona Geol. Soc., Digest, v. 3, p. 111-112, 1960.

Geohydrology and geochronology are significant aspects of a 3-year interdisciplinary study, on "The Utilization of Arid Lands," initiated in June 1958 at the University of Arizona under a grant by the Rockefeller Foundation. The Gila-San Simon Valley has been chosen for intensive investigation.--M. Russell.

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